

**FISCAL YEAR 1992
DEPARTMENT OF ENERGY
AUTHORIZATION
(Fossil Energy)**

**HEARING
BEFORE THE
SUBCOMMITTEE ON ENERGY
OF THE
COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES
ONE HUNDRED SECOND CONGRESS**

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MARCH 5, 1991

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1992 DEPARTMENT OF ENERGY AUTHORIZATION

TUESDAY, MARCH 5, 1991

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY,
Washington, DC.

The Subcommittee met, pursuant to notice, at 1:30 p.m., in Room 2325, Rayburn House Office Building, Hon. Marilyn Lloyd (Chairman of the Subcommittee) presiding.

OPENING STATEMENT OF HON. MARILYN LLOYD, CHAIRMAN, SUBCOMMITTEE ON ENERGY

Mrs. LLOYD. Before we do begin our hearings, I would like to ask for unanimous consent that the Subcommittee permit today's proceedings to be recorded or covered by the media and, without objection, so ordered.

Good afternoon. As we begin our first authorization hearing for this fiscal year, I am extremely pleased that we begin our hearings on the Department of Energy's budget requests with such distinguished witnesses. I believe that this year holds a great deal of promise and as well as opportunity to resolve an issue that has been very sadly neglected, that is, the energy policy of the United States. Certainly, our Energy Committee's particular contribution to this policy will be in the area of civilian energy research, development, and demonstration.

My colleagues and I on the Subcommittee, and, of course, the members on the full Committee have a very difficult, but I think it's a very exciting task before us, because it's certainly the direction we've been moving and working in for the past 15 years. We'll be looking at a multi-year authorization bill containing the authorizations for all energy programs within our Committee's jurisdiction. So it is very important that all of us look at our nation's needs for the near term as we will in the legislation. It is also important that we look at our authorization bill as a long-term blueprint for the future energy policy of our country.

But I'm going to be doing something a little bit different this year. I'm going to be asking our distinguished witnesses for your vision of what you perceive is our energy future. I think in doing so we'll determine which programs in our energy technologies have the greatest opportunity for providing us with sound energy resources. It's not going to be an easy task, by any means, but I think when you look at the limited resources, and I'm sure all of you

here today have seen the extreme cutback in the fossil energy budget, it is very important that we all establish our priorities.

We're very happy that last week we were able to have our distinguished Secretary, the Honorable James Watkins, appear before our Committee to present the National Energy Strategy. On that day and again today I want to congratulate them on this accomplishment. I know it's a very difficult task. It is clear by the number of hearings and testimony received by the Department that they did reach out and search out for guidance from many sectors across the nation.

I think it's pretty obvious that this Committee does not agree with all the policy recommendations in Admiral Watkins' strategy. We're going to try to see what we can do. As I said, it's a good starting to try to improve its effectiveness. We are all waiting the presentation of some sort of formal legislation that will serve as the guidepost to implementing the policy of the Department of Energy.

Of course, our first authorization today is on our budget request for fossil fuels. I'm hoping as the opportunities come before us, that we'll see that there are shortcomings. I do want to express my regret at the low level of the budget submission for our fossil research and development. It follows the trend of many years and with this request of \$227 million, this is a 51 percent decrease from last year's level.

In addition to this, to make bad matters worse, if the Department's request for transferring \$150 million from the Clean Coal Technology to the Fossil Program goes through, we are in trouble. This would leave only \$77 million, if this transfer is not granted. We want to continue our research activities at the federal level. To do so, we are going to have to have adequate resources to carry them out.

Of course, before we go forward, I wanted to mention to all of you how fortunate we are to have such outstanding members on the Subcommittee. We have outstanding members and we also have outstanding staff. We look forward to working with all of you.

Again it's a great pleasure for me to recognize my distinguished Ranking Republican Member, the Honorable Sid Morrison for his remarks. We work together on energy issues so well. I wish that every Committee had as good a working relationship as we do on this Committee. We're looking forward toward a good, positive working relationship. Sid.

OPENING STATEMENT OF HON. SID MORRISON, RANKING REPUBLICAN, SUBCOMMITTEE ON ENERGY

Mr. MORRISON. Thank you, Madam Chairman, and thank you for your very kind remarks. I think if we work well together, it's out of my respect for your leadership.

I am pleased, too, that we begin our hearings working from fundamentally the budget requests, but leading towards authorization efforts of this Subcommittee. Particularly in light of the Persian Gulf Conflict, we have a unique opportunity to help formulate a comprehensive energy policy in which fossil fuels play a major role. I, too, am pleased that we have the National Energy Strategy on

the table now. We can shoot at it from all directions. Most of us have and will continue to do so. It's there and it's the first time in more than a decade that we're working from a comprehensive, well-researched package that combines a number of energy alternatives. So it will be our challenge as we work with the Department and with others to build a consensus that will guide us in the energy world into the next century.

I am pleased to spend some time with fossil fuels. It's not in my particular part of the country, but Lamar Smith is here as the member on our side of the aisle with the greatest interest in this area. I am going to follow his leadership. Of course, we will want to put fossil fuels in the overall, the big picture, in the proper perspective for America's energy. Thank you again, Madam Chairman, for your kind words. We're starting on an interesting trail together, as we have before. Thank you.

Mrs. LLOYD. Thank you very much, Mr. Morrison. Are there members that have opening statements that they'd like to make?

OPENING STATEMENT OF HON. LAMAR SMITH, SUBCOMMITTEE ON ENERGY

Mr. SMITH. Madam Chairman, I have an opening statement, at the appropriate time.

Mrs. LLOYD. The Chair recognizes Mr. Smith.

Mr. SMITH. Thank you, Madam Chairman. Like you and like Mr. Morrison, I welcome the opportunity today to receive testimony from Mr. Gentile on the Department of Energy's Fossil Fuels Research Programs, particularly the oil and gas sections.

Last year, the Department of Energy proposed the Oil Research Program Implementation Plan to refocus its oil research and development efforts. One key aspect of the program was preserving access. Now that oil prices are back to pre-war levels, we must focus our oil research efforts on getting technologies to the field, for example, to extend the life of stripper wells. While long term goals are needed, the oil research program is focused more on putting technologies into the hands of the independent producer as soon as possible. Thank you, Mr. Chairman, Madam Chairman, excuse me.

Mrs. LLOYD. Our lead-off witness today for our hearing this year is the Honorable Robert Gentile. He is the Assistant Secretary for Fossil Energy for the Department of Energy. Mr. Gentile, we know this is not your personal budget. I want you to know that my remarks are not directed at you personally. We're happy to have you with us today, but we will have some questions for you. Please proceed.

STATEMENT OF HON. ROBERT H. GENTILE, ASSISTANT SECRETARY FOR FOSSIL ENERGY, U.S. DEPARTMENT OF ENERGY

Mr. GENTILE. Thank you, Madam Chairman. Madam Chairman and Members of the Subcommittee, it is a pleasure to appear before you again this year to discuss our proposed budget for the Clean Coal Technology and the Fossil Energy Research and Development Programs.

As in my previous appearances before this Subcommittee, I have several of my deputy assistant secretaries available this afternoon to answer more detailed questions, if that becomes necessary.

The budget we have submitted, obviously, reflects the very tight budget times that we live under. It does not include every worthwhile project that could have been proposed. It makes very tough choices on what can be continued, and what cannot.

I would hope, Madam Chairman, that we could view this budget in terms of its overall priorities—and its attempts at some new directions—rather than in terms of whether or not the figures simply represent the same status quo as last year.

As my formal statement indicates, the programs contained in our budget request reflect an initial realignment of priorities based upon the National Energy Strategy.

The NES recognizes the importance of fossil fuels—and advanced fossil fuel technologies—in achieving two of its principal goals. First, improved energy security through a reduction of vulnerability to oil disruptions, and second, enhanced environmental quality.

To achieve these goals, we have requested significant increases in funding that can enhance domestic oil production.

We have proposed a new policy for funding test facilities that produce transportation-grade liquid fuels from coal.

We have placed a very high priority on high efficiencies and ultra-clean environmental performance, particularly in our Coal R&D Program.

And we have recognized the need for a reevaluation of the fifth round of the Clean Coal Program to determine whether it should be restructured to reflect changing market conditions and changing national priorities.

Let me address the Clean Coal Program more specifically. There has been a lot of confusion over our intent regarding the final round of competition under this cost-shared program.

I will admit that several statements contained in portions of the budget that went to press before we finalized our budget proposal have contributed to this confusion. That is why I want to be as explicit as possible in outlining our position. We have not decided to cancel Round 5. Our position is that it should not be run next year for several reasons that I will outline in a moment. But Round 5 could be an important opportunity to help position coal for the 21st Century—if it is structured properly.

On the other hand, none of us wants to see tax dollars spent just to be spending money. So our budget request calls for a suspension of Round 5, a breathing period, you might call it. And during that breathing period, we will reassess several factors. I've listed some of them on page 4 of my formal statement.

For example, the coal-fired power industry of the 21st century will have to live under very stringent emission caps imposed by the Clean Air Bill. That represents entirely new challenges for new power plants, as well as for those that continue to operate.

Global climate change remains a concern—and it is clear that the world's industrialized nations are going to be under increasing pressure to take mitigating actions, even before all the science is in.

We may see increasing attention given to the security of liquid fuels—particularly in the aftermath of the last few weeks and months. And that could change our thinking—or perhaps broaden it—in terms of what the fifth round of the Clean Coal Program should be.

In light of this, we believe the most prudent action is to pause at this point and examine all of these factors. And in conjunction with that decision, we would propose using the \$150 million previously earmarked as the first installment for Round 5 to be used, instead, to offset expenses in the Fossil R&D Program.

Turning to the Fossil Energy R&D Program, we have proposed an effective budget of \$227 million—which includes the Clean Coal offset.

I won't describe each of the items in this budget proposal. Rather, as my formal statement does, let me point out the four major themes that formed the policy guidelines for preparing the budget.

First, an increased emphasis on liquids. This can best be illustrated by our significant increases in funding for advanced oil recovery technology. The chart included in the text on page 5 of my statement illustrates this funding increase.

And I might point out, at this point, Madam Chairman, that it is important to look at the break-out of the Advanced Oil Recovery Program in the manner shown on page 5. Some confusion results when the overall oil figures are shown because they include the oil shale program—funded at \$17 million last year, and zero this year. That difference in funding skews the numbers, if you look only at the overall oil program number.

So it is important to look at the next level down to see that we have asked for nearly a 31 percent increase in funding over our 1991 request for oil production research.

We believe that increase reflects the high priority assigned by the NES to advanced oil production technology—both advanced secondary technology and the longer-range enhanced tertiary recovery.

Also, reflecting the importance given by the NES on liquid fuels, we have included funding for Wilsonville and LaPorte coal liquefaction test units—two projects that we have historically been at odds with Congress in terms of funding requests.

We believe research on advanced liquefaction technologies offers some very promising opportunities—liquids from coal at costs of \$30 per barrel or less—but we want the industry to reaffirm our view. And the best way we see for that to happen is to ask for financial cost-sharing. So our budget request reflects about half the funding needs of these test facilities—and we will ask industry for the remainder.

The second major theme deals with a point I mentioned earlier—namely positioning coal for the 21st century. Throughout our Coal R&D Proposal, we have emphasized higher efficiencies and cleaner performance levels well above today's capabilities. Quite simply, we see those factors being absolutely critical to coal's viability in the 21st century. I've provided some examples of the technologies we are emphasizing in the 1992 budget proposal on page 7 of my statement.

High efficiencies are important because that is the best way we know today to reduce the release of CO₂ carbon dioxide per unit of coal burned. High efficiencies also make economic sense regardless of whether or not we have a global climate change problem to deal with. That is why we call this element of our program part of the "no regrets" policy for dealing with global climate issues.

As I mentioned, ultra-clean environmental performance levels will be necessary for coal to continue to be used under the emission caps now mandated by law for the post-2000 power industry.

We have placed a great degree of emphasis on private sector cost-sharing. As I mentioned with regard to coal liquefaction, private financial involvement is the best yardstick of the private sector's view of the potential of a technology. So, in areas of the budget that are approaching the point where commercial decisions should be made, we are proposing that industry assume cost-sharing in the range of 50 percent.

Obviously, for some of our longer-range, more basic research programs—such as the Advanced Research and Technology Development—such cost-sharing is not practical, and we are not requesting it. But for those concepts that are at the more mature stages of the R&D process, we believe cost-sharing will tell us whether tax dollars are being invested wisely.

The final element of our program reflects the need to operate within tight fiscal constraints. Some programs simply cannot be continued, especially if we want more sufficient funding for higher priority needs. So we have applied some criteria to our programs.

If the program would divert too large a share of the funding pie for a single effort, we simply could not support it. That was the case with the MHD program. It would take more than one-third of our coal budget to support this single line item. We believe the money could be better spent on a more balanced effort.

If there remained little else to do in a program, we did not support funding it. This was the case with underground coal gasification—where virtually all of the technological approaches have been tested. The environmental clean-up activities associated with past test sites for this program have been shifted to the environmental restoration line items of the budget.

If there seemed to be little private sector interest in commercializing a technology—due simply to the lack of economic viability—we could not support it either. This was the case for Oil Shale Development program where the industrial sponsors who offered the best development and commercialization opportunities have cancelled their programs.

And finally, given a choice between technologies that will allow coal to remain strong in its current market or technologies that will help expand coal's markets, we felt the higher priority was on maintaining coal's current market viability. That is why we have proposed to discontinue the Heat Engines Program.

I've included a brief discussion of several other elements of our budget, Madam Chairman, including some that don't require major funding allocations.

But in the interest of time, rather than repeating what is in my formal statement, let me conclude by saying this. While aggregate funding levels may not be as high as previous appropriations, we

believe our budget proposal represents a sound statement of priorities. It has been fashioned within the context of what we have learned during the NES process and what we believe the industry needs will be in the foreseeable future.

I look forward to working with you and members of this committee to translate these priorities into a program that is both technologically and financially sound.

That concludes my opening remarks. I will be happy to answer any questions.

[The prepared statement of Mr. Gentile follows:]

Statement of
Robert H. Gentile
Assistant Secretary for Fossil Energy
U.S. Department of Energy
to the
Committee on Science, Space and Technology
U.S. House of Representatives
March 5, 1991

Madam Chairman and members of the Subcommittee, the FY 1992 Department of Energy budget request for fossil energy-related programs reflects an initial realignment of program priorities based on the development of the *National Energy Strategy* (NES).

Two of the overarching themes conveyed by the NES have particular relevance for fossil fuel related research, development and demonstration. They are:

A. Improving Energy Security by Reducing Vulnerability to Oil Disruptions

As Secretary Watkins said in his Posture Statement accompanying the FY 1992 budget proposal:

"One of the goals of the National Energy Strategy is to reduce the Nation's vulnerability to world oil market disruptions. Accordingly, the Department of Energy will expand its commitment to decrease U.S. vulnerability to potentially unreliable oil supplies and to address this country's nearly total reliance on oil as a transportation fuel."

As I will describe in this testimony, key elements of the Fossil Energy budget proposal that support this goal include significant increases in funding for projects that can enhance domestic oil production from the known oil fields and a continuation of longer-range efforts to develop alternative, coal-based fuels for transportation uses.

B. Enhancing Environmental Quality

The NES places a high priority on environmentally sensitive energy policies. It calls on the Nation's talents in science and technology to develop new or improved approaches for reducing the impacts of energy production, distribution and consumption on the biosphere.

Two key environmental challenges identified in the Secretary's Posture Statement are (1) to meet the requirements imposed by the new amendments to the Clean Air Act, and (2) to address concerns about potential global climate change. DOE's projects in clean coal technology demonstration and in the longer-range research on high-efficiency, low-emitting power systems address these challenges directly.

In addition, as my testimony will describe, the Office of Fossil Energy has undertaken a more intensive effort to address the control of carbon dioxide, one of the "greenhouse gases."

The NES also calls attention to environmental issues related to the Resource Conservation and Recovery Act, the Clean Water Act, and other federal and state regulatory actions that govern the disposal of fossil fuel-derived liquid and solid wastes. DOE's research programs in coal waste management and in enhanced oil recovery can have an important bearing on the reasonableness of future regulations and on their cost-effective implementation.

THE FY 1992 FOSSIL ENERGY BUDGET PROPOSAL

The FY 1992 Fossil Energy budget proposal is divided into two major elements:

- o The Clean Coal Technology Demonstration Program
- o The Fossil Energy Research and Development Program

The Department's FY 1992 budget request for the Clean Coal Technology Demonstration Program provides the second increment of funding for Round #4 of the joint government-industry funded program: \$315 million. It also proposes to suspend Round #5 and to transfer \$150 million of advance appropriations earmarked for the competition in FY 1992 to the Fossil Energy Research and Development account.

The Department's FY 1992 budget request for the Fossil Energy Research and Development Program is \$227 million, before applying the proposed offset from the Clean Coal Technology Program. This budget includes funding for coal research (\$115 million), oil and gas research (\$60.2 million) and other supporting efforts.

THE CLEAN COAL TECHNOLOGY DEMONSTRATION BUDGET

Based on its five-year history, the Clean Coal Technology Demonstration Program must be considered one of DOE's principal "success" stories. Its purpose is to co-finance with industry a series of pioneering projects that will demonstrate innovative methods for using coal cleanly and efficiently.

Since the program was conceived -- as a \$5 billion commitment to the U.S./Canadian effort to resolve the transboundary problem of acid rain -- 35 projects, representing 10 major categories of technology, have been selected from three rounds of nationwide competition and are now active.

Of these, 33 have completed negotiations for cooperative agreements and are now progressing through their intended demonstration efforts. Seven projects are now in operation, and another six are scheduled to be in operation within a year.

Within just the last few weeks, for example, the following major milestones have occurred:

- the first electricity generation from American Electric Power's 70-megawatt pressurized fluid bed combined cycle plant in Ohio;
- the startup of a gas reburning (for nitrogen oxide reduction) and sorbent injection (for sulfur control) technology installed at an Illinois Power Company plant;
- the startup of an advanced nitrogen oxide reduction process at a Georgia Power Company plant;
- the groundbreaking for a new "coal refinery" -- a plant that will produce both clean solid and liquid fuels -- from subbituminous coals in Wyoming.
- the first operation of an advanced pollution control device . invented by the Passamaquoddy Indian Tribe that uses previously discarded waste dust from a cement kiln as a scrubbing reagent.

These projects, and many others in the program, are now generating the construction and operational data that will be needed for the private sector to make more cost-effective pollution control and power generating decisions in the near future.

In mid-January 1991, the Department issued its fourth call for clean coal technology proposals. Round #4 will place particular emphasis on gaining the high-efficiency advantages -- namely, significantly less carbon dioxide production and ultra-low sulfur and nitrogen emissions -- that can be achieved through advanced power generating processes. It will also encourage the demonstration of extremely effective pollution control devices that will become increasingly important for coal plants operating under the 21st century emission caps imposed by the new Clean Air Act.

The success of the Clean Coal Technology Program can be illustrated by the level of industry cost-sharing obtained to date. DOE's total expenditures for projects selected in the first three rounds of competition is now estimated to be \$1.3 billion. The private sector and state agencies have more than matched the federal share, providing approximately \$2.0 billion. Round #4 is expected to add another \$600 million in federal funding, to be at least matched by private sector cost-sharing.

If the level of private sector cost sharing in Round #4 remains comparable the first three rounds, the \$5 billion funding target originally set in 1986 by the U.S./Canadian Special Envoys on Acid Rain will be achieved at the conclusion of Round #4. The pre-2000 Clean Air Act standards appear to be achievable with the projects now in place.

In light of this, the need for a fifth round of competition is unclear at this time. The Administration believes it is important to reassess the final increment of the program principally in light of two issues (in addition to budget constraints):

- (1) The potential need for and feasibility of new technologies beyond the year 2000 to reduce pollutants in conformance with the stringent emission caps imposed by the new Clean Air Act, and
- (2) The potential need for and feasibility of ultra-high efficiency technologies that can reduce concerns over global climate change.

Several technologies in the research stage -- 2nd generation pressurized fluidized bed combustion, advanced coal gasification processes, gasifier-based fuel cell systems, advanced turbine power cycles, magnetohydrodynamics, etc. -- could help meet these needs, but many of these concepts may not be sufficiently mature to compete in Round #5 if it was to be held in calendar year 1992.

In addition, other concerns could emerge, especially as the nation's energy strategy evolves. For example, future energy considerations may place increased emphasis on the use of coal as a source of liquid fuels or for other alternative energy forms, perhaps necessitating a change in scope or intent of the final round of the program.

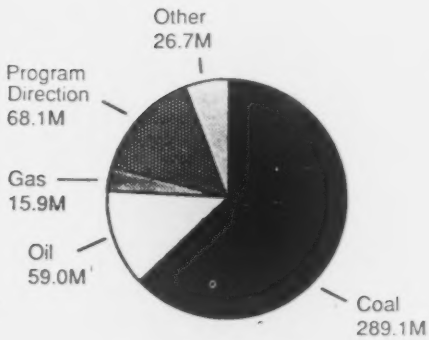
In light of this, the Administration believes the most prudent course of action is to pause at this point in the Clean Coal Technology Program and conduct a thorough reassessment of the requirements being imposed on the energy facilities of the post-2000 future. Therefore, we propose to defer a decision on whether to reschedule Round #5 until the FY 1993 budget process. The \$150 million previously appropriated by Congress for Round #5 in FY 1992 is proposed for transfer to the Fossil Energy research and development account.

THE FOSSIL ENERGY RESEARCH AND DEVELOPMENT BUDGET

The budget for fossil energy research and development is well below the FY 1991 enacted level but 12 percent above the FY 1991 request. The chart on the following page presents the budget proposal in tabular form.

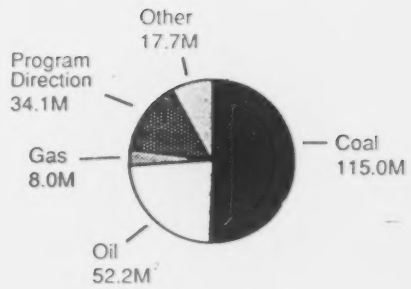
Four major policy themes were used in shaping the FY 1992 budget:

FY 91 Appropriations \$458.8M



¹ Includes \$40 Million for Advanced Oil Recovery and \$17.2 Million for Oil Shale

FY 92 Request \$227.0M



² Includes \$32.2 Million for Advanced Oil Recovery and \$0 for Oil Shale

FY 92 Fossil R&D Budget Request - Summary Chart

Coal	
Activity	Request
Control Tech. & Coal Prep.	\$22.5M
Adv. Research & Techn. Dev.	28.8M
Coal Liquefaction	17.2M
Combustion Systems	18.7M
Fuel Cells	22.4M
Heat Engines	0.0M
Underground Coal Gasification	0.0M
Magnetohydrodynamics	0.0M
Surface Coal Gasification	<u>5.4M</u>
Total	115.0M

Oil & Gas	
Activity	Request
Advanced Extraction & Process Tech.	\$14.8M
Enhanced Oil Recovery	37.4M
Oil Shale	0.0M
Unconventional Gas Recovery	<u>8.0M</u>
Total	60.2M

Other	
Activity	Request
Fuels Programs	\$3.1M
Environmental Restoration	8.1M
Program Direction	34.1M
Plant & Capital Equipment	0.8M
Cooperative R&D	5.7M

(1) Increase emphasis on liquids R&D

Under the current policy and economic scenario, U.S. imports of oil are forecast to rise from 42 percent of domestic consumption in 1989 to as high as 61 percent in the year 2000 and up to 67 percent in 2010 if oil prices remain relatively low. Improvement in U.S. energy security requires efforts on several broad fronts. However, one of the most important near-term actions that can be taken is to enhance the domestic petroleum industry's capability to produce oil from known reservoirs.

Therefore, while budget necessities dictated reductions in much of the fossil energy R&D program, a significant increase is proposed in programs that can enhance the domestic production of crude oil:

Advanced Oil Recovery

(\$ in millions)	FY91 REQUEST	FY91 ENACTED	FY92 REQUEST
Enhanced Oil Recovery	\$27.1	\$31.7	\$37.4
Advanced Extraction & Process Technology	12.9	10.1	14.8
Total.....	\$40.0	\$41.8	\$52.2

The focus of much of this expanded program is to mitigate premature reservoir abandonments and to shift to near-term efforts that can increase oil recovery from existing reservoirs.

Two-thirds, or more than 300 billion barrels, of domestic oil is bypassed or unrecoverable using production methods available today. Also, without advanced recovery technology, wells with operating costs that exceed the value of the produced oil are being plugged and abandoned. The NES places one of its highest energy supply priorities on preserving access to endangered reservoirs that have the greatest risk of abandonment within the next 5 to 10 years.

The FY 1992 budget proposal mirrors this priority by requesting a 30.5 percent increase in funding over the FY 1991 request for advanced oil recovery research and development (see table above). Much of this proposed funding would go toward continuing efforts to identify high priority reservoir classes that face high risks of abandonment and developing the more sophisticated geoscience and production methods that can prolong their useful life. Concurrently, efforts will continue to develop the next generation of improved recovery techniques that can maximize production from these fields and to develop approaches that can minimize environmental impacts associated with oil recovery.

As the NES estimates, by shortly after the year 2000, proposed near-term research and development measures could add 5 billion barrels (at oil

prices of \$20 per barrel) to more than 25 billion barrels (at \$50 per barrel) to the nation's lower-48 oil reserves, which currently total 20 billion barrels. If the program is full successful, the amount of economically recoverable reserves ultimately could be increased by between 20 billion barrels (at \$20 per barrel) and 65 billion barrels (at \$50 per barrel).

A further measure of the importance of this effort is the Strategy's projection that applying near- and longer-term measures to 80 to 90 percent of the known remaining U.S. oil deposits could boost domestic oil production by about 3.2 million barrels per day by 2010. This is, by far, the largest single component of the initiatives proposed by the NES to increase domestic energy supplies by the year 2010.

Over the longer-term, however, it is important to recognize that the U.S. is a mature oil-producing region; its oil fields are aging and although production can be increased during the next two decades by implementing the NES initiatives, domestic reserves will ultimately decline. Eventually the U.S. may have to look to alternative forms of liquid fuels, including the production of transportation-grade fuels from coal. The National Research Council identified \$30 per barrel (at the test facility level) as a reasonable cost goal for the next 5 to 10 years, based on recent technological improvements (although product cost is only one factor in commercialization decisions; the capital investment requirements also create significant business risks).

Several improved liquefaction technologies are now ready for testing at pilot scales. DOE's FY 1992 budget departs from recent budget submissions by recommending federal funding for two major liquefaction test facilities: the Wilsonville (AL) direct liquefaction test unit, and the LaPorte (TX) indirect liquefaction test unit. However, because we believe cost-sharing is the best gauge of whether industry assigns the same degree of importance to these types of projects, the DOE proposal anticipates cost-sharing totaling at least 50 percent from private partners who would join us in these test operations.

(2) Position Coal for the 21st Century

The National Energy Strategy recognizes the important economic, energy security and trade opportunities offered by the U.S.'s abundant coal reserves (about one fourth of the world's known coal). Yet, it is clear that coal's contribution in the 21st century will be shaped by how it can conform to the nation's environmental objectives.

In light of this, DOE's FY 1992 coal budget (\$115 million) focuses on the longer-range challenges imposed by the more stringent Clean Air Act and the possibility that mitigating actions will be necessary to reduce carbon dioxide build up.

For example, in FY 1992, the Department will conclude a 5-year, \$36 million effort to develop acid rain control technologies in its coal preparation and flue gas cleanup programs. Some of the products of this effort are now being readied for commercial use in the Clean Coal Technology Demonstration Program or by completely private initiatives.

The FY 1992 and subsequent coal R&D budgets will increasingly focus on ultra-clean and/or ultra-high efficiency processes that can reduce acid rain precursors by 95 percent or more, and can lower carbon dioxide emissions by as much as 20 to 40 percent.

Work will continue, for example, to develop:

- a) extremely effective flue gas cleanup technologies (with a greater degree of sulfur capture than today's scrubbers and with the integration of nitrogen oxide controls);
- b) more efficient "hot gas" cleanup techniques that can improve the cost-effectiveness and environmental performance of advanced power generating equipment such as gasification-combined cycle and pressurized fluidized bed technology;
- c) higher-performance combustion processes, such as advanced generation fluidized bed concepts and low-emission boiler systems;
- d) advanced generations of fuel cells;
and
- e) improved techniques for producing synthesis gas and coproducts from coal.

In addition, DOE's fossil energy program will expand its efforts in FY 1992 to examine innovative techniques for controlling greenhouse gas emissions. The principal approach for reducing such gases as carbon dioxide has been to boost the efficiency of the energy process -- i.e., using less fuel for the same amount of power production. For the near-term, this approach continues to represent the best "no regrets" fossil fuel technology policy for addressing global climate change concerns. In the longer-run, however, it may become necessary to employ other types of greenhouse gas control systems. DOE's FY 1992 coal budget expands work in the early stages of research on these innovative approaches.

(3) Obtain greater private sector cost-sharing

Private sector cost-sharing offers two major benefits:

- 1) It leverages federal dollars and extends their usefulness;
- 2) It provides a "yardstick" for measuring whether private industry shares the same sense of potential for an evolving technology as does the government.

In tight budget times, both of these benefits increase in significance and value. DOE's fossil energy research and development budget has been constructed with a emphasis on obtaining greater amounts of private sector cost sharing, particularly for technologies that are at more mature stages of development.

For example, the budget proposal calls for 50 percent co-funding targets in such areas as (a) acid rain mitigation technologies in coal preparation and flue gas cleanup, (b) fine particulate control technology, (c) certain aspects of gas stream cleanup, (d) coal liquefaction test facility operations, and (e) the unconventional gas recovery program. Somewhat lower levels of cost-sharing are also anticipated from existing contracts in fuel cell development.

Generally, the Department's view is that non-federal support should increase as a technology matures. Where concepts are in a very early stage of research or are more generic in nature -- e.g., many of the efforts being pursued in the Advanced Research and Technology Development Program, and the Advanced Extraction and Process Technology Program -- DOE will continue to be the principal, if not sole, sponsor. When such concepts evolve into actual engineering prototypes, DOE will increasingly look to the private sector to indicate their interest and support through financial cost-sharing.

(4) Eliminate lower-priority programs that are unaffordable or are unlikely to attract significant industry interest.

In establishing funding priorities for the FY 1992 budget, the Department determined that four activities within its fossil energy program could not be continued. The activities either diverted too large a proportion of funding away from other high-priority programs, or were not likely to attract sufficient industrial interest to offer a smooth path for technology transfer.

The four are:

Magnetohydrodynamics -- Past funding levels (approx. \$40 million per year) would create a severe imbalance in the fossil energy R&D portfolio. Other high-efficiency technologies would likely not receive necessary funding support if this high-cost activity were included in the budget;

Heat Engines -- Limited resources required that programs which are intended to expand markets for coal, such as this one, be given a lower priority. The Department believes that coal-related funding should be directed principally at those technologies that will help coal continue its current contributions to our energy supply mix, namely utility and industrial-based technologies with greater environmental performance and higher overall system efficiencies.

Underground Coal Gasification -- Virtually all technological concepts for the in situ gasification of coal have been field tested, and there seems to be little commercial interest in this approach at the present time. Efforts previously funded in this program, such as environmental activities, have been transferred to the Environmental Restoration budget activity.

Oil Shale -- Oil shale remains a longer-term potential source of liquid fuels but will not be financially viable compared to other alternatives for the foreseeable future. Because of this economic situation, the industrial sponsors that offered the best opportunity for commercializing the technology are no longer proceeding with developmental projects. Given the lack of industry support, the Department believes that funding can be better spent on nearer-term, higher potential technologies for enhanced oil recovery.

OTHER ELEMENTS OF THE FOSSIL ENERGY BUDGET

In addition to the principal funding categories of coal, oil and gas research and development, the Fossil Energy program includes several other supporting or complementary functions.

The Program Direction and Management Support budget proposal, for example, anticipate sufficient funding for 450 fulltime staff positions -- 124 at DOE headquarters and 326 at the DOE field technology centers and project offices.

The Cooperative Research and Development budget will support cooperative programs at the Western Research Institute (Laramie, WY) and the University of North Dakota Energy and Environmental Research Center which are 50-50 cost shared with non-Federal clients.

Environmental Restoration funding would be directed toward cleanup and other related efforts at several sites of previous federally-funded fossil energy activities, in addition to the removal of asbestos at the Morgantown and Pittsburgh Energy Technology Centers.

The Fuels Program funding will support the continuation of DOE's legally required regulatory activities involving the export/import applications for natural gas, export applications for electricity, permits to construct new international electric transmission lines, and certifications of coal capability by electric utilities.

NON-BUDGET RELATED INITIATIVES

There are several elements of the Fossil Energy program envisioned for FY 1992 that do not represent large budget expenditures but, nonetheless, are important elements in carrying out the priorities identified in the National Energy Strategy. The Strategy places a great degree of importance on improving science and math education and increasing public awareness of new energy innovations as a key to maintaining the nation's scientific and technological preeminence.

In line with these priorities, the Office of Fossil Energy has initiated a significant education related effort with a goal of improving the awareness and understanding of elementary and high school teachers and students of the advances in fossil fuel technology. Working principally through channels offered by the National Science Teachers Association, the Office is distributing student handouts and teacher lesson plans that explore the new technologies of coal, oil and natural gas. Teacher seminars and on-site educational workshops are also elements of the Office of Fossil Energy's increasing attention to the pre-university educational community.

In a similar fashion, the Office of Fossil Energy has initiated an effort to increase public understanding of clean coal technologies. Based largely on a series of recommendations by the National Coal Council, the Office is carrying out an expanded effort to improve the technical understanding of clean coal technology at the state and local level, among technology users and vendors both domestically and overseas, and within the environmental community.

Comparable types of activities are underway in the Oil and Gas Programs. Already, important technology transfer initiatives are underway in such efforts as the "Cross-Well Seismic Forum" (now involving 23 companies) and other elements of the DOE/FE National Laboratory-Industry Oil Partnership. As activities increase in the Oil and Gas Programs -- especially as we implement the current research plans in coordination with industry and state organizations -- we envision expanding efforts to improve technology awareness/transfer.

CONCLUSION

The FY 1992 Fossil Energy funding proposal reflects a balancing of priorities within a very constrained budget. Not all worthwhile projects have been funded. We believe, however, that the budget represents a sound commitment to meeting the needs of the fossil energy industry. The priorities set in this budget reflect both needs and concerns expressed to us by industry. Many of the projects and programs will be carried out by industry in partnership with the federal government.

I look forward to working with the Congress in meeting the objectives set forth in the National Energy Strategy in a way that is both technologically and fiscally sound.

Mrs. LLOYD. Thank you very much, Mr. Gentile. I would like to say for the members that we are going to try to be very fair in this hearing. Sometimes I'll start out and sometimes I'll finish up. But we will abide by the five minute rule and we'll recognize members in order of their appearance. At this time, I'm going to recognize Mr. Morrison.

Mr. MORRISON. Thank you, Madam Chairman. Mr. Gentile, we appreciate having you here and your testimony. I noticed some interesting fundamental shifts in your budget priorities. Could you tell us how much of that shift is driven by the Clean Air Act and the fact that Congress finally put that together? Was that really a factor in your budget determinations?

Mr. GENTILE. Yes, sir, I think the Clean Air Act, among other things, was a factor in how we structured this budget. Clearly, the post-2000 emissions cap is going to significantly impact the power industry. That certainly had an impact on how we shifted our R&D program. The play that global climate change is getting certainly has impacted our program. We're spending more time looking at higher efficiencies and CO₂. Clearly both the Clean Air Act and global climate change and some other issues, liquids, those have all had a major impact on our budget formulation this year.

Mr. MORRISON. I noticed, too, you've moved on more aggressively to the advanced technologies. While you describe some of the reasoning in your short statement you gave us, I sense this is sort of skipping some of the near term activities. Is this part of your evaluation process on what's important to industry, that if they have not invested in things that you are really bringing almost to developmental stage that that is a clue to you that maybe you are working on the wrong subjects?

Mr. GENTILE. Yes, sir, there are several things involved. Some of the projects we were working on clearly would not have met the 2000 cap, so some of those programs have been dropped. Industry involvement is very important to us in this program. If we don't see industry interest in commercializing the technology, it does us little or no good to develop that technology. So we clearly look for that industry interest. As a technology matures, as it reaches nearer and nearer to commercialization, we would expect more and more industry interest. If we have a technology that is reaching commercial deployment and there is no industry interest, it tells us that it has been a nice scientific effort, but perhaps not the best in deployment technology.

Mr. MORRISON. Do you have some sort of an advanced notification in the system to the industry that you can say far enough in advance that you can get their attention that you're considering dropping this program, unless they're willing to invest in it?

Mr. GENTILE. It is pretty evident through the history of the fossil program. We have, in the fossil program in the R&D side, about 23 percent cost-share right now. So we have a very heavy involvement on the part of the private sector. As the technologies reach deployment, for example in the Clean Coal Technology program, there is a 62 percent private cost-share in there. So it's sort of built in the program. It's the philosophy that's been behind the fossil program for many years.

Mr. MORRISON. Except in Clean Coal Technology, you're pulling out \$150 million and want a delay, even with industry involved?

Mr. GENTILE. Well, yes, but that's not the reason for the delay. The Round 4 was delayed because of the Clean Air bill, so we missed that schedule with Round 4. The delay on Round 5 is intended more to take a breather and look at some of these more advanced technologies. In Round 4, we have already looked at more efficient technologies, and we clearly give preference to those technologies. One of the elements in looking at which technologies we'll fund has to do with efficiency. I think as we move towards Round 5, we'll see even more of that. So it's clearly a breather in that regard.

Mr. MORRISON. I remember the fights around here on funding for Clean Coal Technology. What if Congress doesn't agree to your \$150 million from that program to fund Fossil R&D. What are your plans then for the fossil program, since that is a major shift? Do you have a contingency plan?

Mr. GENTILE. Our proposal, sir, is to fund part of the Fossil R&D Program with \$150 million of the Clean Coal Program. If that were not Congress' desire, we would certainly have to go back and re-think how we would approach that program, the R&D Program.

Mr. MORRISON. Thank you. Thank you, Madam Chairman.

Mrs. LLOYD. Thank you, Mr. Morrison. Mr. Wolpe.

Mr. WOLPE. Thank you very much, Madam Chairman. Mr. Gentile, if I understand the numbers correctly, you're proposing to spend some \$52 million for enhanced oil recovery in the fiscal year 1992. Could you indicate, I did not see it broken out for the out years, how much you propose to spend for enhanced oil recovery over the next five years?

Mr. GENTILE. I would have to supply that for the record, sir. I don't have it, off the top of my head. I will say that when we moved forward with this new oil plan, we started it last year, we reported to Congress what our intent was. It is a multi-year program. It looks at many different oil reservoirs and the funding levels change. I don't know what the out year of the plan is right now. I'll be happy to submit it.

Mr. WOLPE. Can you give us a ball park, some rough indication?

Mr. GENTILE. I would have to supply that, sir. I know that it ramps up and probably, in about the fifth year, reaches its highest level and then ramps down. Because, what we're doing, is about every year, we're taking on two classes. We're planning on working our way through ten different classes of reservoirs, so it's clear that in the fourth and fifth year, that we're doing most of the bulk of the work on all the reservoirs. So it ramps up probably around the fifth year. I would be happy to supply that for the record.

Mr. WOLPE. Assuming that you will be getting a \$52 million figure now, even by the fifth year, you're talking in the range of maybe \$100 million, somewhere in that range, \$75 to \$100 million?

Mr. GENTILE. Yes, probably.

Mr. WOLPE. So over a five year period, the outer limit would be less than \$500 million dollars, probably anywhere from \$350 to \$500 million total? Is that correct?

Mr. GENTILE. I'm sorry, in five years?

Mr. WOLPE. Over a five year period, you're talking about roughly \$350 million?

Mr. GENTILE. Probably about \$350 million, I would guess.

Mr. WOLPE. Yes, somewhere in that range, okay. The National Energy Strategy indicates in its calculations that this will displace some 1.4 million barrels of oil a day by the year 2005, is that correct?

Mr. GENTILE. Yes, sir.

Mr. WOLPE. I'm asking these questions because I'm trying to understand the relative cost effectiveness of different kinds of R&D investments that we are making here. If we can increase the production by such a large amount, and it's a pretty sizeable amount, with relatively small investment, why won't the domestic oil industry pay for that particular R&D? What does the Federal Government have to do that?

Mr. GENTILE. The major issue with the oil program is that the problem that we're facing in this country is our reservoirs are maturing. A figure that I often use, in this country we have approximately 620,000 oil wells, each pumping on average about 10 barrels a day. In Saudi Arabia, you've got about 580 oil wells, producing over 6,000 barrels a day. So we're in a very mature oil regime. What we're facing, are reservoirs that because of the low productivity and the high lifting costs, they are being abandoned. In this country, we've only produced about one-third of the oil that is in place. For every barrel that we produce in this country, there is about two more barrels sitting in the ground. What we're trying to do with this program is tap our existing resource, not go out and find more oil, not go out and find more fields.

Mr. WOLPE. I understand that, but I'm not sure that's relevant to the question. The question is that what you're suggesting here is a relatively modest investment of \$350 million in that range of a five year period will yield a displacement of oil of some 1.4 million barrels a day.

Mr. GENTILE. We think that that investment will yield about 15 billion barrels in the near term, zero to five years, and an additional 60 billion barrels in the ten year period, in terms of oil reserves. So that's about 75 million barrels of oil. That's a considerable amount of oil that is sitting in place right now in areas we're already producing oil from.

Mr. WOLPE. What is your calculation as to the dollars per barrel of oil that would be generated in that fashion?

Mr. GENTILE. I'd have to run those numbers through and get them back to you.

Mr. WOLPE. Would you do that, please, for the record.

Mr. GENTILE. Yes, sir.

Mr. WOLPE. It is still not clear to me why the gain that is projected here is as substantial as it apparently is at such a minimum investment, and it's not something that the oil industry might itself want to take on.

Mr. GENTILE. I think you described the oil industry as being monolithic. I don't think the oil industry is monolithic.

Mr. WOLPE. I wasn't describing it in any way.

Mr. GENTILE. So much of what we're producing in those reservoirs are done by independent producers, by small operators.

They're done by stripper wells. What we're trying to do in this program is bring the most cost effective, current technology first to those who don't have it, all right, so it's a tech-transfer element. Then we bring along with it some of the technologies that will help us get that additional oil out of the ground and the wells are already in place.

Mr. WOLPE. I'm not sure you have responded to the question, but let me move on. On page 10 of the National Energy Statement, it's indicated that the \$2.5 billion in new tax breaks for the oil industry in last year's budget bill will result in only some 400,000 barrels of oil a day additional production. If we can spend about \$350 million to get 1.4 million barrels of oil per day, why should we be spending \$2.5 billion to get only 400,000 barrels of oil a day? It doesn't sound like a very smart investment, does it?

Mr. GENTILE. I think that you'll find that the tax breaks that we're talking about in terms of tax incentives have a great economic impact, both on state and local governments.

Mr. WOLPE. And also on the federal taxpayer, I'm sure.

Mr. GENTILE. And also on the taxpayer, but it's in terms of the money received from that investment in terms of tax credit at the state and local level. So it's not just in terms of barrels of oil, but also in terms of the economic impact across the country.

Mr. WOLPE. Yes, so you are suggesting this is an economic development program that goes beyond the oil industry?

Mr. GENTILE. No, I'm suggesting that there are independents out there who are having a very tough time surviving and the tax incentive was worked out in Congress as part of the budget summit. I would not second guess what Congress' wisdom was in making that decision. I'm telling you that the impact of that in terms of the impact of the state and local governments in terms of tax receipts and in terms of keeping oil production in place is significant. I guess the point I would only make is I would think from the standpoint of national policy, the question we should be asking ourselves is if we have \$2 billion to spend, are we getting the maximum displacement of oil at the lowest possible cost, spending it through tax break route, as occurred in the summit agreement?

Mr. GENTILE. Well, I certainly think that is an issue, but I would point out that the tax credits preserve access. Through the use of the tax credits, those companies can continue in place, producing those wells they are producing. The R&D effort is geared toward additional recovery. So it's two slightly different items.

Mr. WOLPE. I can think of all sorts of subsidies that helped preserve various interests of one type or another. I'm not sure that's a good response to the public policy question. I assume that the goal here is to try to find some means of becoming more energy self-sufficient here?

Mr. GENTILE. I agree. I think that preserving access to run oil fields is very important in that.

Mr. WOLPE. That's right, to an extent, but the issue is how does that weigh, how does one compare that relative cost to investments in other kinds of energy technologies or other kinds of initiatives? I'm just simply trying to advance the notion that I don't think we do that kind of cross-comparison analysis very much. I think we respond to these various technologies to the various proposals on a

very ad hoc basis. I'm trying to suggest it might be useful for a change if we could attempt to apply some kind of objective economic criteria as we make these judgments. I guess to you, do you think that the \$2 billion tax credits are as wise, from a cost-effective standpoint in displacing petroleum, as the proposal you're advancing today, in terms of the \$500 million yield a far larger displacement?

Mr. GENTILE. I think they're both necessary in the short run. If you didn't have the tax credit situation, in three to five years, those fields would no longer be open to develop the future oil that's in the ground. That's the problem we're facing. They're being abandoned at such a rapid rate, we have to do something to preserve access to those fields.

Mr. WOLPE. Thank you very much.

Mrs. LLOYD. Thank you very much, Mr. Wolpe. Mr. Smith.

Mr. SMITH. Thank you, Madam Chairman. Mr. Gentile, I'm a little concerned by a change in the Department of Energy's priorities. Last year the Oil Research Program, as I mentioned to you a few minutes ago, targeted the Permian Basin and assigned it the No. 1 priority when it came to targeting the oil fields. This year, it has dropped back to a second priority and the Deltaic Reservoirs have moved into first priority. Can you explain to me why the changes occurred and what you know now that you didn't know a year ago when you assigned the Permian Basin the top priority?

Mr. GENTILE. Yes, sir, last year we knew that our top two or three basins were going to be the Deltaic, the Fluvial Deltaic, and probably the Carbonate Reservoirs. What we found in looking at the two reservoirs, in looking at the first reservoir, the Deltaic Fluvial, we had a chance of recovering a great percentage of oil, using advanced secondary recovery. When we move to the carbonates, it's going to take more of the tertiary and EOR types of recovery. In the short run, we thought it would be more effective to go to the advanced secondary. Also, the Deltaic Fluvial had a greater percentage of oil in place and a higher risk of abandonment than the carbonate did.

Mr. SMITH. Is the Permian Basin still a top priority that you have?

Mr. GENTILE. Absolutely. The Permian Basin is in the second class of reservoirs, which is the carbonate reservoirs, which we're also starting to work on.

Mr. SMITH. Do you expect the funds and the technology to get to the Permian Basin in the next year or two?

Mr. GENTILE. We are starting the second reservoir class in this also.

Mr. SMITH. Wonderful, I'll be back in touch with you about the exact times on that. As you know, the Permian Basin, which includes West Texas and a very small part of New Mexico, accounts for something on the order of 17 percent of the U.S. production of oil and gas. That being the case, why aren't there field offices, federal field offices, in the Permian Basin area, and do you expect any field offices to be opened any time soon?

Mr. GENTILE. Congressman, we looked at the idea of field offices, and I guess we made a policy decision that it was better to spend the money to bring the individuals together, the different oil groups together, and getting our technology out there, rather than

putting it into bricks and mortar in terms of the capital costs of running an office. The whole structure of the oil plan is to identify a reservoir group across the country, bring those parties together, work on the problems and work on the solution, and have a very aggressive outreach and technology development.

Mr. SMITH. Right. I would only urge you, considering the amount of energy produced by that one relatively small area, and given the needs of the independent oil men in the region, that you might reconsider. I think there is a question of need. It is not just the reservoir itself, but a question of needs as well that might need to be addressed on that score.

Let me go to the next question, if I may, Madam Chairman, if I may. That is, the wide ranging price of oil, as you know, has fluctuated all the way from \$40 to \$15 over the last year or so, and has made it awfully difficult to attract investors to the industry. Is there anything that the Department of Energy is doing, do you have any specific plans or incentives in mind in regard to federal research funding programs that would involve the independent producer? By the way, I want to correct myself before I go, I keep saying "independent oil man". I don't mean to be so sexist. I'm going to start saying "independent producer", but that is what I want to ask.

Mr. GENTILE. We do a lot of work with independents, Congressman. One of our most successful programs is the National Lab Industry Partnership. We've got players such as Mark Riffi and Harvey Yeats operating in that program. We have a Horizontal Well Program in Oklahoma with another company. We have several of those ongoing projects. In terms of the actual implementation plan, the independents have been very heavily involved in planning and developing the oil program as it moves forward. They will probably have the largest play in this oil program. We would see the field activity occurring largely among the independents. We've had a rather incredible growing interest by the independents in our oil plan.

Mr. SMITH. Right. Given the programs that you've mentioned, and there are obviously some other programs that could be initiated, given the needs and the interests of the independents that we've been talking about, I think that might argue even more though for a field office in a region of the country that produces so much oil and gas. We'll be back to you on that. The last question, as you've probably heard from the independent producers, they feel like they are getting very little support in trying to cope with some of the environmental compliance problems that they see hitting them pretty hard. One example that I've been told about is, for example, many of the regulations are written from a universal environment point of view and don't take into account, for example, different climates. You'll have the same environmental regulation apply to temperate coastal as well as desert climates. Is there anything that can be done in that regard to try to address the differences in the regional or prevention environment and thus make it easier for some of these independents to comply with the environmental regulations?

Mr. GENTILE. Sir, we're very concerned about the impact of existing and new legislation and regulations on the oil and gas industry.

Coming up facing the industry is the Clean Water Act and the Safe Drinking Water Act, in addition to everything that is currently in place.

Mr. SMITH. You say you are concerned, but what steps are you taking?

Mr. GENTILE. What we're doing right now, we are looking at all of those issues. We're also worked very closely with the Interstate Oil, IOCC, in trying to develop what makes good, sound environmental regulations. We're working with the states to figure out how we can work through those issues—wetlands, discharge, there is a very active program with this. Of course, those regulations don't come out of energy. We see what those impacts are going to have on energy production, try to argue that case, and try to see how we can best mitigate those impacts on the production of energy.

Mr. SMITH. We appreciate all your efforts in that regard. Thank you, Madam Chairman.

Mrs. LLOYD. Thank you very much. Mr. Bruce.

Mr. BRUCE. Thank you. Mr. Gentile, I'm curious about your attitude toward the development of the coal resources in the country. What do you believe would be a precise statement of the attitude of your Department toward developing coal?

Mr. GENTILE. I would say that coal is seen to be past, present, and future, a keystone of the energy base of this country. It's a very available, reliable, and inexpensive energy source. The key to development of that resource is defining and developing the technology that it uses that resource in an environmentally sound way.

Mr. BRUCE. So you want to define and use the technology. To that end, do you increase and get as close to that goal by delaying Round 5 or by continuing with Round 5 of Clean Coal Technology projects?

Mr. GENTILE. I would say that depends on what the goal of that project is. We clearly see that technologies have come on line in the first three rounds of the program that are dealing with the pre-2000 scenario. I think what we have to look at in Round 4 and, especially, Round 5, are the post-2000 scenario. In the situation we're going to have, we're going to need more and more power plants that have to be very highly efficient, that have to be good environmental performers in a post-2000 world. That is clearly what we're trying to see in Rounds 4 and 5 of our program.

Mr. BRUCE. So you delay Round 5?

Mr. GENTILE. We're suggesting to delay Round 5 right now since Round 4 was delayed for almost six months, I believe, so we think we need a breather right now to rethink Round 5 and move in that direction.

Mr. BRUCE. In talking to Secretary Watkins, he didn't give me any idea that we were delaying Round 5 for only six months. Are you saying that we're only going to delay it for six months?

Mr. GENTILE. No, we're proposing to delay it until 1993, and make the decision in 1993.

Mr. BRUCE. All right, so it is a much longer delay than six months?

Mr. GENTILE. Yes, sir, it would be a year.

Mr. BRUCE. And so if you were trying to see beyond the year 2000, you believe that our vision would be clearer if we delay research than if we conduct it and have the knowledge from that research, is that your statement? If we delay the money this year, it seems to me, that the less money we spend on research, the clearer our vision will be, under your theory?

Mr. GENTILE. No, sir. The money that was offset was not money that would have been used this year had we run the program regardless. We just simply would not have spent that money in that fiscal year. We are using that money to offset activities that we do need on the R&D side. The issue of Clean Coal Round 5 is one of deferments. The Administration feels we need to defer it until 1993 to look at it in that context of the new Clean Air Act and the delay of Round 4.

Mr. BRUCE. When you talk about transferring the \$150 million into fossil fuel, is that the money we're talking about transferring?

Mr. GENTILE. Yes.

Mr. BRUCE. That money was not going to be spent anyway?

Mr. GENTILE. It would not have been spent. We would have just been starting the process with Round 5. We really did not need that \$150 million in the course of that year. We would not have spent that amount of money in that fiscal year.

Mr. BRUCE. You are asking for cost-sharing. What is going to be the criteria for cost-sharing?

Mr. GENTILE. We currently have a very active cost-sharing program. As I stated earlier, in the R&D side of fossil energy, we have about a 23 percent cost-share across the board. In the Clean Coal Technology Program, we have a 62 percent cost-share. The criteria used will be as a technology gets closer and closer to commercialization, we will be expecting more and more cost share from the private sector to demonstrate their interest in commercializing the technology. That has been carried through the fossil program for many years.

Mr. BRUCE. Is that printed anywhere, your criteria for cost-sharing?

Mr. GENTILE. I don't believe it is, I'm not sure. I don't think we can think of that, but that has clearly the philosophy of the fossil program for many years.

Mr. BRUCE. Do you consider the difference in size of the company, small versus big, and their ability to contribute to the cost of the program.

Mr. GENTILE. Not really. We've had a mix of large and small companies in our cost-shared R&D throughout the history of the program. Clearly, it becomes more difficult, sometimes, for the smaller companies, but on the other hand, we have some small companies that have started the R&D and brought their technology all the way up through the Clean Coal Technology Program. One that comes to mind is the noxo technology, that started at the Pittsburgh Energy Technology Center as an R&D project. It is now a Clean Coal Project in Ohio at Ohio Edison. So we have both, big and small.

Mr. BRUCE. All right. It is amazing to me that for research projects, you have deleted, or transferred, \$150 million. You have a \$77 million project left, but you say that you emphasize and want

to develop coal. Your budget figures belie the fact of your statements of being interested in coal. I just cannot be convinced that your heart is in your statement. I thank the Chairman.

Mrs. LLOYD. Thank you, Mr. Bruce. Mr. Barton.

Mr. BARTON. Thank you, Madam Chairman. I want to tell you how much I appreciate being on this Subcommittee with you. I look forward to working with you. It's good to be back after a six year layoff.

Mrs. LLOYD. We're all happy to have you here. We've got good members on this Committee.

Mr. BARTON. I believe so. Mr. Gentile, I want to take up, to some extent, where Congressman Wolpe left off. I agree with many of the points that he made, in terms of the cost effectiveness and return on investment in terms of the assets that we put into our advanced Oil and Gas Recovery Program, but I don't believe I would totally agree with his conclusions. I think he was attempting to make the point that perhaps the private sector should put more money and the Federal Government less money. Now, he didn't say that explicitly. I would say something of the opposite.

You know, I read your testimony with a lot of interest. I think the paragraphs, the verbiage is excellent. On page 5, you talk about the amount of oil imports going up. It says "a significant increase is proposed in programs that can enhance the domestic production of crude oil", a significant increase. In fiscal year 1991, the amount that we are spending is \$41.8 million. Your budget request is \$52.2 million, so basically, a \$10 million increase. Now, my math is somewhat weak, but I believe we are importing about \$6 million barrels of oil a day. It's under \$20 a barrel now, it's around \$17.50. But, if you take \$20 a barrel oil times \$6 million, that's \$120 million a day. A significant increase on behalf of the Department of Energy appears to be \$10 million. That's a lot of money, in Texas where I live, but it is not even peanuts in terms of the impact.

Again, Congressman Wolpe said that the private sector should invest in these technologies. I agree with that. I think some of the cost sharing programs that you instigated in the Clean Coal Technology area are role models. But some of these small independents, if you go to Corsicana, Texas, and you go to the oil field in Corsicana that was founded in 1902, you've got these little pump jacks that consume 50 percent of the cost of the oil in electricity just to pump a barrel and a half of oil a day out of these little, you know, five foot pump jacks. Those folks don't have the resources. Now, if we develop some advanced technology, they'll use it, but they can't invest in it. So, my first question to you, if you're expecting to get 3.2 million barrels of enhanced oil recovery over the next ten years or whatever, why in God's name don't we put more than a \$10 million increase into this part of your budget?

Mr. GENTILE. Well, clearly, it's a matter of priorities and a matter of money in a very tight budget time. What we've done is try to take an amount of money that seemed reasonable in terms of the budget and we've clearly shifted some emphasis. It's evident that the oil recovery is very important to us. We've moved more money into that area. It's not going to be enough to solve all the problems.

Mr. BARTON. \$10 million is going to do literally nothing. I mean, it will do something. But, you know, if we were somewhere in Texas in a poker game, I would say that you're talking trash. You're talking a good game, but you "ain't delivering." You're not putting your cards on the table. I believe I'm correct in stating that last year the reason the number was as high as it is this year is because Congressman Chapman on the Appropriations Committee basically doubled the amount that the Department of Energy was requesting. Now I may be incorrect, but I don't think I'm incorrect.

I'm one of your friends on this panel, you know. I want to encourage you to go back to the Department of Energy, talk to Admiral Watkins and to Deputy Secretary Henson Moore, and let's see if, in fact, you want a significant increase that can enhance the domestic production of crude oil, let's do it. I believe you will find the support on this Subcommittee. I feel fairly confident you'll find the support at Full Committee, and then in the appropriation process. But, don't play word games with us. Don't talk well and then not deliver.

Now, a second question, on your Fuel Cell program, last year, in the Clean Air Act, I offered an amendment that is now law, that requires a hydrogen fuel cell demonstration program to develop a hydrogen fuel cell for automobiles. That's a different kind of fuel cell than the testimony that we're going to hear today, but I think it's relevant, given the fact that 70 percent of our oil is being refined into gasoline for transportation uses. Are you aware of what, of anything the Department of Energy has done to begin to implement the grant proposals for this hydrogen fuel cell program?

Mr. GENTILE. No, I'm not, sir. That would be in the Conservation part of the Department, but I would happy to get that answer for you.

Mr. BARTON. Okay, I guess the last point, Madam Chairman, I do want to reiterate what Congressman Wolpe said. Whatever money we put into the coal and gas area, I do think it should be in a cost-share arrangement. I do think we should try to be as cost effective as possible with it. I do hope that we'll develop some programs that require, to the largest extent possible, that the private sector be involved and put some of their money on the table, too. Thank you.

Mrs. LLOYD. Thank you very much, Mr. Barton. Mr. Gentile, where do you expect coal to fit into the energy mix, in the near and the long term? What would be the primary role? What percentage of energy supply mix can we look to coal to contribute?

Mr. GENTILE. I would think that coal is going to continue about where it is in the immediate, the projected future. I say that because so much of our power generation right now comes from coal. We think that will continue. If you look at the world and look at where the economies are growing and look at their indigenous energy resources, it's clearly coal. So we'll continue to see coal-firing, both in this country, and in the developing economies.

Mrs. LLOYD. Do you think it's going to contribute 20 percent?

Mr. GENTILE. No, it will probably contribute closer to about 50 percent to 60 percent for the foreseeable future.

Mrs. LLOYD. The near future?

Mr. GENTILE. Yes.

Mrs. LLOYD. What about long term?

Mr. GENTILE. In the longer term, the next 20 years.

Mrs. LLOYD. I'd like to turn to the MHD Program. We spent about \$640 million on the program. We need about \$70 million more for proof of concept and then to go to the demonstration phase. We've not requested funds for it again. What technologies is the MHD Program competing with?

Mr. GENTILE. The MHD technology is clearly one of the most exciting of the advanced technologies. It would be competing with the advanced fuel cells and the advanced third generation integrated gasification combined cycle. It is a little further out in terms of fruition, but it clearly has the promise of being a very high efficiency performer and an environmental performer, as do these other technologies I mentioned.

Mrs. LLOYD. Where do you think it is going to go if we don't give it any money this year?

Mr. GENTILE. I think it is going to have a little tougher road. We still think the technology may be ready for proposal under Round 5. If we don't finish the funding on MHD, I think it means that industry is going to have to take a little greater risk in bringing that forward.

Mrs. LLOYD. Do you think it can apply for Round 5?

Mr. GENTILE. Yes, I think so.

Mrs. LLOYD. We're talking about cost-sharing. Here's a technology where we have cost sharing, and you're dropping the ball.

Mr. GENTILE. Clearly, Madam Chairman, we made a decision not to fund the program. Basically, I couldn't rationalize putting 35 percent—34 percent of my budget into one technology. That had us very concerned.

Mrs. LLOYD. I think this is even more basic than the MHD Program. When we ask industries—and I believe in cost-sharing, and this is a philosophy that every member of this committee is going to share with you. When we ask industry to cost share, and then we do foolish things such as dropping our commitment for MHD, Mr. Gentile, this isn't right. We can't ask industries for cost-sharing, when we aren't going to keep our part of the bargain. This is not done in good faith. If we make a commitment to cost-share, then I think we should keep our part of the bargain. This troubles me, as I see technology after technology. We're not as good as our word. I think this should be a major consideration as we develop an energy strategy. If we can't make the private sector believe in us, and they put their hard earned dollars into a technology, then we in good faith should keep our share of the bargain. What are our international competitors doing with MHD right now?

Mr. GENTILE. In MHD, we're doing most of the work in coal. The Soviets are doing some work in gas-fired MHD. They seem to have a fairly good commitment to that. It's done at their Institute of High Temperature Technology. They have not done work in magnet development. It's been mainly gas-fired MHD. We're clearly in the lead in MHD.

Mrs. LLOYD. I'm equally interested in fuel cells. I think that coal may serve as a primary energy source for our fuel cells. I think this work is very pertinent to our energy mix. When do you expect the molten carbonate development to be commercial for coal?

Mr. GENTILE. Well, the molten carbonate, we would expect on the gas side to be ready about 1995 and on the coal side, about the year 2010.

Mrs. LLOYD. What's the status of the Solid Oxide Program for commercialization?

Mr. GENTILE. What is the Solid Oxide Program, the status?

Mrs. LLOYD. Yes.

Mr. GENTILE. I'm sorry, well, the status is that that is an ongoing program. It's going well. We think that the first generation solid oxide will probably be ready by the year 2000 in gas and about the year 2010 in coal, with second generation in coal being ready by the year 2020.

Mrs. LLOYD. What's the state of development of our competitions in fuel cell right now?

Mr. GENTILE. In the phosphoric acid fuel cells, both the United States and Japan are commercializing that technology. In the molten carbonate and in the solid oxide, it's pretty much nip and tuck, but I would say we're just slightly ahead in both technologies at that point.

Mrs. LLOYD. In the 1991 Appropriations Bills for oil shale activities, there was an \$8 million line item for a Western Oil Shale program that was cost-shared with Occidental Petroleum. Since the passing of this legislation, as it is well known that Occidental pulled out of the program. Where is our \$8 million? What are we going to do with that? Have we zeroed this out or can we put this \$8 million somewhere else?

Mr. GENTILE. No, we can't, Madam Chairman. That \$8 million was geared towards a specific tract. It was just for that project. There's very little we can do with that. That was project specific to that oil shale project and that tracked. So we talked to the Appropriations Committee and, basically, we're not going to be doing anything with that. They will be using that money in the next appropriations bill. But that is specific to that project. We can't use it elsewhere.

Mrs. LLOYD. That's going back into, well, the money was appropriated.

Mr. GENTILE. It was appropriated for that CB tract which Occidental was operating.

Mrs. LLOYD. Thank you very much, Mr. Gentile.

Mr. GENTILE. Thank you, Madam Chairman.

Mrs. LLOYD. Our next witness is Mr. Frank Burke, he represents the National Coal Association. I asked him to provide us with the Association's perspective of the future role of coal research and development. We're happy to have you with us.

STATEMENT OF DR. FRANCIS P. BURKE, DIRECTOR, APPLIED RESEARCH, CONSOLIDATION COAL CO., ACCOMPANIED BY DOLORES M. KERN, DIRECTOR OF RESEARCH, DEVELOPMENT AND TECHNOLOGY TRANSFER, NATIONAL COAL ASSOCIATION

Dr. BURKE. Madam Chairman, my name is Frank Burke. I am the Director of Applied Research for Consolidation Coal Company, a DuPont subsidiary. Seated with me here at the table is Dolores Kern, who is Director of Research and Development for the Nation-

al Coal Association, on whose behalf I am testifying today. The National Coal Association members mine the majority of the coal produced in the United States.

America's coal reserves constitute 90 percent of our total fossil energy resource. The U.S. coal reserves contain energy equivalent to more than the world's total proven oil reserves at the end of 1988. In addition, coal is our only significant national energy export. Coal contributes \$4 billion annually towards the positive balance.

Although estimates of future coal production and use vary, the estimates all bear one common feature—the curves all point up. The 1990 Energy Information Agency forecast is that coal will increase from 31 percent of our domestic energy production in 1990 to over 40 percent by the year 2010. For these reasons, coal is the strategic American energy resource.

The development of advanced coal use technologies through research and development is one of the most effective and appropriate means for government to implement and achieve the goals of the National Energy Strategy. However, the risk to private sector investment in new fossil energy technologies is great, in part, because of our highly uncertain regulatory environment. By sponsoring research and development, and encouraging private sector investment in technology innovation, government and society can ensure the rewards of energy security and environmental enhancements.

Most of the coal produced in this country is used to generate electric power, and 55 percent of our electricity comes from coal. Electricity demand is forecast to increase at an annual average rate of 2.4 percent over the next decade. This increased demand cannot be met with current and planned generating capacity.

Advanced electric generating systems, such as pressurized fluidized beds and gasification/combined cycle systems are needed, which can increase power generating efficiency to over 40 percent, generating 25 percent more electricity for the same amount of coal burned.

Therefore, we strongly support the continued development and demonstration of these technologies by maintaining current program funding levels and competing Round 5 of the highly successful Clean Coal Technology Demonstration Program. We also support more fundamental research and development to provide the basis for the next stage of electrical generating technology development.

Utilities are now making Clean Air Act compliance decisions. Coal can continue to be the long-term fuel of choice if economical and efficient technologies are available during this decade and beyond the year 2000. More advanced scrubbers and control options can reduce capital and operating costs and increase fuel efficiency. We also support the development of retrofit emission control technologies, such as duct sorbent injection technology.

Securing an adequate technology menu also requires the continued development of direct and indirect coal-fired turbines, efficient coal refining processes, improved technology for by-product utilization, and ultra-efficient electric generating technologies, such as

molten carbonate and solid oxide fuel cells and magnetohydrodynamic systems.

The U.S. transportation sector is 98 percent dependent on petroleum. Cost competitive, coal-fired diesel engines should be developed. This program requires the development of engine retrofit technology, coal-fuel production and handling technology, and emission control systems.

In these three areas, electric power generation, environmental protection and transportation, the government can best serve our energy future by maintaining a broad based program of fundamental energy and fuels research and technology development, and by continued funding of the Clean Coal Technology Demonstration Program. In terms of budgetary commitment, any reduction below current funding levels would severely impair the Fossil Energy R&D Program.

The government also should make maximum use of its existing research facilities, including those National Laboratories that have not been highly active in fossil energy research in the past.

The National Coal Association took the initiative last year to create a more effective partnership between the coal industry and the National Labs. We are impressed by the technical excellence of the staffs and their strong sense of mission in effecting technology transfer to industry. A model technology transfer program, known as the Oil Recovery Technology Partnership, is already in place. We strongly believe that a similar program with the coal industry would yield extensive benefits to energy security in the United States.

I thank you, Madam Chairman, for this opportunity to speak to you today.

[The prepared statement of Dr. Burke follows:]

Statement of

**Dr. Francis P. Burke
Director of Applied Research
Consolidation Coal Company**

on behalf of

The National Coal Association

before the

**Subcommittee on Energy
Committee on Science, Space, and Technology
United States House of Representatives**

March 5, 1991

Madame Chairman, I am Dr. Francis P. Burke, Director of Applied Research, Consolidation Coal Company, a Du Pont subsidiary. I am pleased to be here today as a representative of the National Coal Association (NCA). NCA is an organization representing producers of coal from the smallest to the largest, operating in all producing regions of the country and mining all qualities of coal. NCA member operations comprise the majority of the coal production in the United States.

America's coal reserves constitute almost 90 percent of our oil, natural gas and coal reserve energy inventory. For this reason alone coal is a strategic energy resource, and is our only significant energy export contributing a positive \$4 billion towards the trade balance.

The demonstrated reserve base is 472 billion tons, and the current estimate is that 236 billion tons of this coal can today be recovered with today's technology and at today's price level.

This recoverable reserve is larger than any other known coal reserve in the world. It represents 34 percent of the proven world recoverable coal reserves outside China, according to the World Energy Conference. It is the rough equivalent of more than 1 - trillion barrels of oil, more than the world's total proved oil reserves at the end of 1988. It also is the equivalent of 5.6 million trillion cubic feet of natural gas.

Although estimates of future coal production and consumption vary, they share one common feature - the curves all point up. The Department of Energy forecasts show that consumption of energy in

the United States is expected to increase at a 1.2 percent annual rate for the next 20 years to total 108.4 quads (quadrillion Btu) in 2010. This is a 30 percent increase in energy consumption over the 1988 level of 83.4 quads. The 1990 Energy Information Agency base case forecast shows coal growing from 31 percent of our domestic energy production in 1990 to over 40 percent by the year 2010.

Coal's role in a national energy plan is central. Fossil fuel research and development goes hand-in-hand with establishing a viable national energy strategy. Such a strategy must focus on the issues of energy security and environmental enhancements. These critical geopolitical and social objectives may not be adequately addressed without government leadership. As a result, fossil fuel R&D, and particularly coal R&D, dovetails well with national energy strategy concerns because the increased use of coal, coupled with innovative new technologies will result in a continuing environmental enhancement, while simultaneously strengthening our energy security.

Increased coal use will clearly be critical to domestic energy security in the decades beyond. And yet, the risk to private sector investment in new fossil fuel technologies is so great, in part because of our highly uncertain regulatory environment, that there is a critical role for government-assisted research and development.

No single technology can solve the problems of energy efficiency and environmental protection. Therefore, we support the

development of a menu of technology choices so that individual users can select the option best matched to their site - specific needs.

Most of the coal produced in this country is used to generate electric power. Electricity met 29 percent of end-use energy consumption needs in 1976. That figure had risen to 36 percent by 1989, and is projected to be 41 percent by 2000 and over 45 percent by 2010.

Electricity is the most environmentally benign and efficient end-use energy, and the United States will increasingly rely on it. In 1990 the Department of Energy released reports that forecast electricity demand will increase at an average annual rate of 2.1 percent between 1989 and 2010. These demands cannot be met with current and planned generating capacity. Compounding this problem is that by 2000, 25 percent of existing capacity will be 50 years or older. This capacity must be replaced with new capacity or repowered.

Current coal-fired electric power generation units in the United States operate at an average 33 percent thermal efficiency, with some older units below 30 percent. Advanced systems such as pressurized fluidized bed combustion and gasification/combined cycle systems can increase power generating efficiency to over 40 percent, thereby burning 25 percent less coal to produce the same amount of electricity.

Therefore, we strongly support the continued development and demonstration of these technologies, with emphasis on maintaining

current program funding levels and completing Round V of the highly successful Clean Coal Technology Demonstration Program. We also encourage continued support of research and development to solve the technical problems, such as hot-gas clean-up, which will provide the foundation for the next stage of electrical generating technology development.

With the passage of the Clean Air Act revision, utilities are beginning to make SO₂ emissions compliance decisions. Coal can continue to be a long-term economic fuel of choice in many existing markets. To accomplish this, economical and efficient technologies must be available that meet environmental needs during this decade and beyond the year 2000. Previous wet scrubber technology requires up to 5 percent of the power plant's output. More advanced scrubbers and other control options would reduce the capital and operating costs of the plant and will slightly increase the fuel conversion efficiency of the power plants. Plant output to power these scrubbers is significantly reduced.

In keeping with the menu concept, we also support the development of retrofit technologies. For example, the Department of Energy now supports an active retrofit development program for what is known as duct sorbent injection technology. One of the first Clean Coal Technology projects to be completed demonstrated duct sorbent technology.

We also support the continued development of direct and indirect coal-fired turbines; coal refining processes capable of efficiently producing or utilizing the energy contained in coal;

improved technology for by-product utilization; molten carbonate and solid oxide fuel cells; and magnetohydrodynamics.

The transportation sector of the U.S. economy is both a means to move energy resources to end-use markets and a major consumer of energy. According to the Interagency Commission on Alternative Motor Fuels, "Reliance on conventional fuels has left the U.S. transportation system 98 percent dependent on petroleum..... Transportation accounts for more than two-thirds of the nation's petroleum use and more than 80 percent of the high-value light products."

Timely development of coal-fired diesel engines which are capable of competing on a cost-effective basis with conventional diesel powered locomotives now in widespread use, invite continued DOE support. Such a program should address, at a minimum, the following: engine retrofit technology; coal-fuel production technology; emission control requirements; and fuel delivery and storage systems requirements.

The government can best serve our energy future by maintaining a broad based program of support for fundamental energy and fuels research, technology development, and by continued funding of the Clean Coal Technology Demonstration Program. In terms of budgetary commitment, any reduction below current funding levels could severely impair the fossil energy R&D program.

The government also can promote fossil energy R&D by making maximum use of its existing research facilities, including those national laboratories which traditionally have not been highly

active in fossil energy. The National Coal Association took the initiative last year to create a more effective partnership between the coal industry and the National Laboratories.

The process began in August when ten representative of the coal industry met for two days with researchers at Los Alamos National Laboratory. A second meeting took place in November at the Morgantown Energy Technology Center, and subsequent visits are planned for the Pittsburgh Energy Technology Center and Argonne and Oak Ridge National Laboratories.

We were impressed by both the technical excellence of the staffs and their strong sense of mission in effecting technology transfer to industry. A model technology transfer program is already in place, known as the Oil Recovery Technology Partnership. The Partnership's mission is to stimulate, facilitate, and/or coordinate the development and transfer of technology to the U.S. oil industry through technical information interactions and collaborations with the National Laboratories. We strongly believe that a similar program could be formulated between the national labs and the coal industry.

Thank you Madame Chairman for the opportunity to appear before you today.

Mrs. LLOYD. Thank you, very much, Mr. Burke. Where should coal research and development take us in the near term and the longer term as part of our National Energy Strategy? What is the role of the mix of coal?

Dr. BURKE. We believe that coal is now and will continue to be a dominant energy source, a domestic energy source, in the U.S. fuel economy. In terms of the near term, I think that coal use is going to be dictated primarily by environmental considerations. Utilities are currently making compliance decisions, based on the Clean Air Act that was passed last year. So the principal activity, I think, in fossil and coal energy research over the short term is going to be in those areas that are primarily driven by environmental compliance decisions.

In the long term, I think we see that energy efficiency is going to be the dominating feature in technology selection. So we're looking towards those higher efficiency technologies, in the mid-term, technologies like gasification combined cycle, pressurized, fluidized beds, which are coming on now. Some of these are being demonstrated under the Clean Coal Technology Program. We say those are the technologies of choice, both because of their high energy efficiency and because of their excellent environmental performance. Longer term, we see potential for these very high, ultra high efficiency technologies like hydrodynamics and fuels cells, which again, are extremely clean technologies and probably offer the ultimate in terms of energy efficiency and production of electricity from coal.

The other thing that we see is an opportunity to view coal is in non-traditional markets, aside from the primary market, now, is electrical power generation. Coal is a hydrocarbon, like petroleum and natural gas. We think we should view coal as a hydrocarbon and look for opportunities to utilize coal in nonconventional areas. For example, we talked about the coal-fired diesel or direct fired turbines. With the idea of a coal refining system, we can take coal and convert it into upgraded fuels. You are going to hear testimony on coal liquefaction today. I think that would be one type of coal refining or coal upgrading system which we would support.

Mrs. LLOYD. Last week at hearings of the full committee, David Freeman's testimony, and I paraphrased his words, I don't have his testimony in front of me, but we said something to the effect that we will, because of the global warming and our concern about clean air, that we would move away from coal in the next century. Do you think this is going to come about? Would you like to reply to Mr. Freeman's statement?

Dr. BURKE. I think that it's understood that carbon dioxide emissions from coal are a concern. I think that's why we're putting such a high emphasis on the development of these ultra-efficient technologies. The higher the efficiency of the technology, the less coal is burned to produce a given amount of electricity, the less carbon dioxide is emitted. I think that is the direction we are looking at. Based on these premises, coal will continue. Because of its prominence, availability, and price, it is going to continue to be looked on as a primary source of energy, a fundamental energy source, for electric power generation in this country. Our mission in R&D is to develop the technologies to use it in a manner that

produces the least environmental impact. So we support the development of these high efficiency technologies with a view that coal is the only realistic source for energy, electrical power production, particularly, in the long term in this country.

Mrs. LLOYD. You mentioned the role of National Laboratories for fossil research and development. As you know, the Energy Technology Centers at Pittsburgh and Morgantown have really been the lead laboratories for our fossil research and development. I was just wondering with our limited budgets, how you propose spreading this money to the other laboratories. With \$77 million, we barely have enough money if we wanted to close them down.

Dr. BURKE. Yes. PETC and METC, Pittsburgh and Morgantown Energy Technology Centers have long had, it's called the main line responsibility for energy R&D. We're not proposing any diversion of funding from the programs which those laboratories conduct and administer. What we're talking about is trying to cash in on some of the intellectual capital that we believe has accrued in the National Laboratories in research areas that up until now have not been applied specifically to the fossil areas. What we're supporting, we're talking about taking what's already available in the National Laboratories in terms of advanced technology, seeing what is there that is applicable to coal, and attempting technology transfer to use that to benefit coal.

We had a meeting last November, August, pardon me, at Los Alamos National Laboratory. There were ten members of the National Member Companies who met for two days with the staff of Los Alamos Lab. It was a remarkable meeting. I think there were a number of things. These were people that hadn't been working traditionally in fossil fuel energy areas. Los Alamos has a great amount of experience with what is called ground sciences, which are very relevant to coal, because of their underground nuclear testing work. They know how to build instrumentation packages, put them down in a hole, and these are all technology areas that could be very applicable to coal.

Mrs. LLOYD. Do you feel that there are generic technology areas that would not be competing?

Dr. BURKE. I think very much so. I think, as I said, there is a real intellectual capital that is available there. It's a question of seeing what is available there and seeing what uses are for coal. That is a process that we've undertaken, that the NCA has undertaken, to try to identify these elements of those programs which we think could be applicable to coal production or coal utilization research, and try to build a mechanism for technology transfer to fully avail ourselves.

Mrs. LLOYD. This is a very interesting concept for this Committee. I'd like you to provide a little bit more specific information where you feel that this generic research could be done.

Dr. BURKE. I'd be happy to do that.

[The information follows:]

National Coal Association
and
The National Laboratory Initiative

(in answer to question posed during hearing, lines 1279-1282 in testimony).

Significant opportunities exist for the coal industry in the field of research and development of new technologies and the transfer of that technology to both the domestic and international marketplace.

The clean coal technology market worldwide is expected to be \$80 billion per year by the end of this century, according to industry experts. In order for the coal industry to take advantage of this potential market opportunity, NCA is striving for better co-ordination amongst industry/government and universities in the area of research developments and technology transfer. This coordination can be characterized as a search for partnership. There are at least 5 new technology transfer advisory boards in EPA and DOE alone. NCA is taking advantage of tracking and participating in current and future activities of these boards to realize continued growth of the coal industry.

Admiral Watkins, the Secretary of Energy, has declared that the National Laboratories are the intellectual jewels in the U.S. crown, and consider them to be the future proving ground of America's continued preeminence in the technology arena.

The National Laboratories seek to make their facilities and expertise available to industry, not to compete with private firms, but rather to facilitate the transfer of their federally funded research and development efforts to the private sector. Such interaction can result in commercialization of a product or process, transfer specialized knowledge from the labs to industry, provide an opportunity for industry to use the specialized knowledge of scientists and engineers, and keep the labs' staff cognizant of industrial technology needs.

The Secretary of Energy Advisory Board was established in early 1990, to serve as the Secretary's primary mechanism for long-range planning and analysis of major issues facing the Department of Energy. The Board is advising the Secretary on the research, development, energy and national defense responsibilities, activities, and operations of the Department and to provide expert guidance in these areas to the Department. The National Coal Association is participating in this activity through membership involvement on this Board.

A sub-group of this Board has been formed as a 10 member task force to provide advice to the Secretary of Energy on the research, development, energy, and national defense responsibilities, activities and operations of the National Laboratories and the management of those labs. Some issues they are deliberating include:

- o Where are the current and likely future strengths of the National Laboratories? What sets of missions would they be best suited to in the 1990s?

- o How are relationships and partnership among performers of research, or between performers and users of research, likely to change in the coming decade? And
- o As the research missions of the labs evolve to meet the challenges of the 1990s, and perhaps grow more diverse, how should the management of the labs by DOE evolve?

A first step towards interacting with the National Laboratories and energy technology centers was taken by the National Coal Association with a meeting in August of 1990, at Los Alamos National Lab. This two day visit served as a pattern for visits to other facilities. In November of 1990, the second visit in the series took place at Morgantown Energy Technology Center. Future visits are being planned for Pittsburgh Energy Technology, on April 10, 1991, then Oak Ridge National Laboratory and Argonne National Laboratory. NCA hopes to establish an on-going relationship with each of the facilities to include a formal "memorandum of understanding" with each.

Following is a brief description of each lab including areas of research that may have eventual application in either coal production or coal combustion:

ARGONNE: Argonne, IL; FY 1989 Operating Budget \$297 million
FY 1989 Staff 3,905

ANL conducts applied research and engineering development in nuclear fusion and other energy technologies and scientific research in basic physical and life science. Primary program areas: nuclear energy, basic energy sciences, conservation and renewable energy, and environmental research.

LOS ALAMOS: Los Alamos, NM; FY 1989 Operating Budget \$952 million
FY 1989 Staff 7,800

LANL's primary mission is the application of science and technology to problems of national security, including the maintenance of a strong defense, the fulfillment of arms control commitments, and the guarantee of a secure energy supply for the future. Primary program areas: weapons, nuclear, human genome, environmental studies, and oil recovery technology.

OAK RIDGE: Oak Ridge, TN; FY 1989 Operating Budget \$425 million
FY 1989 Staff 4,484

ONRL's primary mission is to carry out applied research and engineering development in fusion, fission, and other energy technologies and scientific research in basic physical and life sciences to underpin work in the energy technologies.

METC: Morgantown, WV; FY 1989 Operating Budget \$226 million
FY 1989 Staff 278

METC R&D includes developing technologies to increase coal utilization in an environmentally acceptable manner. Their goal is to expand the technology base for oil, gas, and coal production, conversion, and utilization. Primary areas: coal gasification, fluidized-bed combustion, gas stream cleanup, heat engines, and underground coal

gasification.

PETC: Pittsburgh, PA; FY 1989 Operating Budget \$150 million
FY 1989 Staff 300

PETC has established a National Coal Technology Data Center where users may have access to government databases on coal research. Primary areas: coal preparation, advanced combustion, flue gas cleanup, alternative fuels, and coal liquefaction.

Mrs. LLOYD. This Committee has been working on technology transfer for a long time. We seem to have many institutional problems to transfer this technology to the private sector. It's more difficult than it should be. Do you have any recommendations on how we could sort of speed up technology transfer?

Dr. BURKE. I would say as far as the national labs program that I have discussed, really we've taken a first step there. I don't know that at this point I could give you more of a prescription for how we should proceed. I think we will evolve that. In terms of identifying impediments, I think at this point we've seen some potential and we are undertaking a process that I hope will lead us to technology transfer if we identify impediments. We may identify some impediments in the course of doing that.

One thing I would say is that at least on the production side, the coal industry has not traditionally looked to research and development to solve its problems. You have, in a sense, a certain cultural difference between the research and development community and the coal production community. I think there is a difference in terms of timing of objectives. The coal industry looks very short term, and is very much bottom line oriented. I think all of these things are, in a sense, cultural impediments. I think the thing we have to do to overcome them is identify promising technological options or technological possibilities, and put together a formal mechanism such as we've talked about with these industrial partnerships. It will help to overcome that cultural gap and provide a formal mechanism to institute some these things, put them into practice, and actually come up with something that is of practical benefit out of these concepts. I think if you do that, that will tend to overcome the impediments and it will tend to create an atmosphere in which you can further develop additional opportunities for technology transfer.

Mrs. LLOYD. Thank you. Mr. Morrison.

Mr. MORRISON. Mr. Burke, I noticed that your testimony includes your support for staying with the schedule on the completion of the Round 5, in other words, no delays, and hand on to the \$150 million. Is that accurate?

Dr. BURKE. Yes, that's the position NCA has taken.

Mr. MORRISON. How does your industry react to the cost-sharing rugs sort of being pulled out from under your feet?

Dr. BURKE. I think in terms of Clean Coal Technology, specifically, that program that we have and, as Mr. Gentile testified, the federal program mandates 50 percent cost-sharing. In fact, the cost-sharing level by industry has been about 63 percent. I think we're satisfied that the Clean Coal Technology has been very highly successful in identifying technologies that were ready for demonstration and developing industrial support for that demonstration. I think where we'll find a difference in terms of the issue of cost-sharing is for those technologies which we would say are not ready for demonstration at this point and, therefore, are less likely to elicit industrial cost-sharing. Nevertheless, our technologies are identified as having an important role to play in our National Energy Strategy, in that regard, I think that we would consider that the federal role in terms of cost participation demands a much higher level of federal participation.

Mr. MORRISON. With the department in that arena, I guess our concern, as Madam Chairman has indicated, is where an industry is playing an active role in cost share and, all of a sudden to have it disappear, will probably discourage you from helping develop and demonstrate other technologies using that same process?

Dr. BURKE. Yes, I think that any break in the continuity of those resources would be devastating to those programs. I guess what we attempted to state in this is that we felt that those funding levels should be maintained, for a couple of reasons. Obviously, you lose continuity in the program. I think the other thing is that you lose continuity in terms of the people. I think you are going to see an exodus if there is that kind of a drastic reduction in funding for these programs. People just simply aren't going to stay with it, in terms of either individually, or on a corporate basis.

Mr. MORRISON. We are considering here doing some legislative process on technology transfer as part of energy research and development. I think what I hear you saying is that you can't transfer that technology unless there is cooperation that you can count on through the process until it gets to the market place. Is that a fair statement?

Dr. BURKE. That's correct. Until the technology is ready for demonstration, I think it has to. But I believe that that is the point at which, in this country, at least with a program like Clean Coal Technology, we made a decision that technologies that are ready for demonstration should command a high level of industrial cost-sharing. In fact, that has been successful in Clean Coal Technology. Those programs beyond Clean Coal Technology are in addition to that. They are part of the fossil R&D budget. We think that a higher level of federal cost participation is required.

Mr. MORRISON. Just one last question, how in the world does a coal-fired diesel engine work?

Dr. BURKE. It works by taking the coal and grinding it, removing the ash from it, the mineral matter component, and slurring it in water. Essentially what you're doing is making a substitute oil. It's a liquid; it's a flowable liquid. It can be injected into the engine. Coal, as I said, is a hydrocarbon. It requires modification to the engine. It requires modification to fuel preparation handling systems. It's not as simple as taking a conventional diesel engine. There is an engine development that is required.

Mr. MORRISON. This intended use would be for large vehicles, light diesel locomotives?

Dr. BURKE. Locomotives, long haul locomotives would probably be the primary. Right now, that is how the program is directed. General Electric is doing a locomotive program. They will, I believe, next year have an operative locomotive running with a coal-fired diesel engine.

Mr. MORRISON. Marvelous. Back to the future. Thank you, Madam Chairman.

Mrs. LLOYD. How efficient is it to provide the energy to make the fuel?

Dr. BURKE. How efficient is the fuel production itself?

Mrs. LLOYD. For the coal-fired diesel.

Dr. BURKE. I couldn't give you an exact number, Madam Chairman. I think I would have to provide that number to you for the record.

Mrs. LLOYD. Very good.

[The information follows:]

Question from Mrs. Lloyd, line 1398.

"How efficient is it to provide the energy to make the (coal-fired diesel) fuel?"

The energy consumption for coal-fired diesel fuel depends on the fuel specifications and production method. Assuming the fuel is made by a physical method such as oil agglomeration, the primary energy consumption is in grinding the feed coal. According to a 1988 report to DOE by Arthur D. Little (DE-AC21-85MC22182), coal slurry fuels would require grinding to a 20-75 μm top particle size and a 4-15 μm mean particle size (D50). As shown in the table, the grinding energy consumed to achieve this would be in the range of 100-200 kWh/ton of coal ground, or about 1-3% of the energy content of the coal. Assuming that the electrical energy used for coal grinding is generated from coal at 35% efficiency, the gross energy consumed is equivalent to 3-8% of the coal ground for slurry fuel production.

TABLE

SUMMARY OF GRINDING ENERGY FOR VARIOUS SIZE REDUCTION EQUIPMENT

Mill Type	Feed Rate TPH	Particle Size		Product D50 Size, μm	Grind Energy, kWh/ton
		Feed	Product		
Gundlach Crusher	25.30	-6"	-1/4"	425.0	1.3
Gundlach Crusher	200.00	-6"	-1/4"	425.0	1.0
KVS Rod Mill	20.00	-2"	-8M	200.0	13.4
KVS Rod Mill	200.00	-2"	-8M	200.0	6.7
BAW Ball & Race	2.50	-3/4"	75% -200	32.0	20.1
BAW Ball & Race	20.00	-3/4"	75% -200	32.0	6.7
BAW Ring-Roller	25.00	-1 1/2"	75% -200	32.0	9.4
BAW Ring-Roller	105.00	-1 1/2"	75% -200	32.0	8.0
Boliden VibroBall	2.50	-1/4"	80% -200	26.0	26.9
US Filter ACM200	5.00	-3/4"	85% -200	22.0	26.9
US Filter ACM300	7.50	-3/4"	85% -200	22.0	26.9
Boliden Vibroball	0.25	-1/4"	80% -325	16.0	40.3
Bepex Hammer PC76	11.25	-1/2"	80% -325	16.0	29.8
Majac-20	4.00	-1/4"	90% -325	10.0	100.7
Majac-30	6.00	-1/4"	90% -325	10.0	100.7
Bepex Hammer PC76	7.50	-1/2"	90% -325	10.0	44.8
Drais Perl Mill	1.00	-10M	-325M	3.0	100.7
Bepex Hammer PC76	1.50	-1/2"	-325M	3.0	223.8
Stur. Micromizer	2.00	100M	-325M	3.0	201.4
Aljet Pulvafet	3.00	-1/4"	-325M	3.0	134.3
Majac-20	1.00	-1/4"	90% -10 μm	2.5	402.8
Majac-30	1.50	-1/4"	90% -10 μm	2.5	402.8
Majac-20	0.50	-1/4"	-10 μm	0.7	805.7
Majac-30	0.75	-1/4"	-10 μm	0.7	805.7

Mr. MORRISON. What you need is, of course, nuclear energy to generate the electricity to grind the coal to mix with the water so you can inject it into a former petroleum-burning engine.

Mrs. LLOYD. Mr. Morrison, that is my point. [Laughter.]

Mr. MORRISON. Thank you.

Mrs. LLOYD. Mr. Fawell.

Mr. FAWELL. Thank you, Madam Chairman. I'm sorry. I have obviously come late on the scene here. I'm just attempting to read the testimony. I'm not at this point going to propound some questions, but I would like to reserve the right to send some questions to you, if I may, when I get a little better hold on what the testimony has been up to this point. Thank you.

Mrs. LLOYD. Thank you very much, Mr. Fawell. We're certainly happy to welcome another one of our new members we're just so happy to have with us, Mr. Cramer.

Mr. CRAMER. Thank you, Madam Chairman. Mr. Burke, I'm a new member of Congress, green and fresh from the hills of North Alabama there in Huntsville, Alabama, so I'm Congresswoman Lloyd's neighbor, slightly to the west and to the south there.

Mrs. LLOYD. He's a good neighbor, too.

Mr. CRAMER. A product of the TVA program there, as well. I wanted to ask you as couple questions about the Coal Research Program. How much emphasis is that program giving to environmental issues?

Dr. BURKE. A substantial amount, in terms of the Coal Research Program, if you looked at the numbers. I think that the two issues that really dominate the coal research agenda are environment and efficiency.

Mr. CRAMER. Okay.

Dr. BURKE. Efficiency is, in a sense, an environmental issue as well, because efficiency results in resource conservation; efficiency results in less potential for pollution and less waste. I think you can tie a great deal of the coal research activities that the Department of Energy funds to either environmental or to efficiency. I couldn't give you a precise number and I think they would probably be better qualified. Speaking from a perspective of not just the DOE now, but I'll say from a National Coal Association perspective, a great deal of what we do, that we call research and development, is environmental in one form or another, either in terms of meeting environmental regulations regarding coal production and use or looking towards coal utilization technologies which are going to help preserve the position of coal as the fuel of choice for the future.

Mr. CRAMER. You see that emphasis on environmental issues continuing under the research program?

Dr. BURKE. It is certainly continuing or increasing.

Mr. CRAMER. Speaking of coal reserves, how much coal that was produced was consumed by the electric utility industry.

Dr. BURKE. There was about one billion tons of coal produced last year. I think the number is about 80 percent of that was consumed to make electric power.

Mr. CRAMER. 80 percent?

Dr. BURKE. 10 percent to steel and 10 percent to exports.

Mr. CRAMER. Okay, thank you.

Mrs. LLOYD. Thank you very much, Mr. Cramer. Thank you very much, Mr. Burke. This hearing is rather long today. So are going to be sending questions to all of our witnesses for you to answer to give us further insight for our record.

Mr. CRAMER. Thank you, Madam Chairman.

Mrs. LLOYD. Thank you very much, and thank your assistant. Would you identify your assistant.

Dr. BURKE. I'm sorry, I'd like to introduce Dolores Kern. Dolores is the Director of Research, Development and Technology Transfer for the National Coal Association.

Mrs. LLOYD. We're happy to have you with us, too. Thank you very much. Next we have a panel on coal liquefaction technology. Our two witnesses are Mr. Gary Styles, who is Manager of Advanced Fuel Utilization for the Southern Company Services and Mr. Lawrence I. Wisdom, Vice President of HRI. Mr. Styles, if you will proceed, and Mr. Wisdom, we'll let you follow Mr. Styles.

STATEMENT OF GARY A. STYLES, MANAGER, ADVANCED FUEL UTILIZATION, SOUTHERN COMPANY SERVICES, INC.

Mr. STYLES. Thank you, Madam Chairman and members of the committee. My name is Gary Styles and I am manager of Advanced Fuel Utilization for Southern Company Services.

Mrs. LLOYD. I believe you need to move the microphone a little closer in. They are pretty direct microphones.

Mr. STYLES. I appreciate having this opportunity to give our company's views on the future of fossil fuels. Southern Company Services manages research efforts on technologies that can help the Southern Companies produce power more efficiently and cleanly.

Southern Company Services believes that fossil fuels should have an important and continuing role in meeting our domestic energy needs. Coal is the United States' most abundant domestic fuel resource, and accordingly, Congress has recognized the importance of fostering its use.

The Administration's National Energy Strategy asserts that the nation should attempt to benefit from its enormous, low-cost coal reserves. The strategy also recognizes that a variety of efforts are necessary to reduce the cost, investment risks, and environmental impact of coal use. At the same time and contrary to the National Energy Strategy, the Department of Energy has submitted a budget for fiscal year 1992 that reduces fossil energy research and development by approximately 60 percent.

While Southern Company Services recognizes the need for national budget restraints and agrees that some reductions in the federal budget may be desirable, we believe that a 60 percent reduction contradicts the Administration's stated intent to boost efforts to produce alternative fuels from coal and to broaden end use of the products of coal research and development.

This proposed cut is particularly harsh in light of the concurrent recommendation to require 50 percent cost-sharing on many research and development contractors.

As a company that has invested millions of dollars to develop technologies that will benefit the entire nation, we believe that this level of cost sharing is too high. For large scale demonstration

projects, such the Innovative Clean Coal Technologies Initiative, with near term commercialization objectives, the 50 percent cost-sharing requirement is somewhat reasonable. On the other hand, for longer term technology development, a 50 percent investment requirement may prove simply too large for many companies and will prevent some important research from proceeding.

While many electric utilities are not small companies, they have traditionally been technology users, not technology owners. In general, electric utilities invest in technology for the benefit of their customers, not for their stockholders. At the same time, we believe it is important that technology users, like utilities, participate in the technology development to assure that it will be understood, accepted, and therefore, commercialized more quickly.

To illustrate how coal research can produce useful results, I can point to a number of promising coal technologies. For example, government-sponsored research has been instrumental in helping develop gasification and pressurized combustion technologies. These technologies can be used to re-power existing coal-fired power plants, to refuel combustion turbines, to reduce dependence on petroleum, or to add new base load capacity for electric utilities. Before they can be fully developed and employed, however, additional development is necessary, particularly in the gas stream cleanup area.

Another technology is advanced coal cleaning, using agglomeration or flotation. This technology may provide industries and utilities with a process to produce low sulfur, low ash compliance coal from medium to high sulfur coal. When perfected, this technology in the hands of fuel users will help increase the supply and limit future cost increases of low sulfur coal.

Coal liquefaction technology can be used to produce clean liquid fuels for transportation, for power generation, or as a chemical feed stock. Significant improvements in the economics of in producing coal-derived liquids have been made in recent years, for example, a 57 percent decrease in cost has been realized between 1983 and 1990. The highest barrier to coal-derived liquids is the need to reduce production costs so that these fuels can economically compete with petroleum.

Status reports, commercialization estimates, funding requirements and program objectives are included in my written testimony that has been submitted for the record.

In conclusion, I would like to say that great strides have been made in developing technologies for innovative coal use. This program would not have been possible without the strong and consistent support from the Federal Government has lent to this research and development effort. With so many possible direct and indirect benefits from the program on the horizon, Southern Company Services believes the Fossil Energy Research and Development Program is worthy of continued Congressional support in its own right and as a part of a larger national energy strategy for the coming decade and beyond. Thank you.

[The prepared statement of Mr. Styles follows:]

FY 1992 FOSSIL ENERGY BUDGET PROPOSAL

Testimony of
Gary A. Styles
Manager, Advanced Fuel Utilization
Southern Company Services, Inc.

Committee on Science, Space, and Technology
Subcommittee on Energy
U.S. House of Representatives

March 5, 1991

Introduction

Mr. Chairman and Members of the Committee:

Southern Company Services, Inc. ("SCS") is a part of the Southern electric system. The role of SCS is to provide technical and management support to the five operating companies that comprise the electric system.¹ Among other things, SCS conducts research efforts on technologies that could help system operating companies produce power more efficiently. In particular, the system, SCS and its operating companies have supported research that would help the nation utilize its coal resources without harming the environment. As a result, SCS is currently participating in both the DOE Clean Coal Technology program and the DOE Fossil Research and Development program.

The Role of Fossil Research in a National Energy Strategy

SCS believes that fossil fuels should have an important and continuing role in meeting our domestic energy needs. As often noted, coal is the United States' most abundant domestic fuel resource and, accordingly, Congress has recognized the importance of fostering its use. Now, in light of the recent crisis in the Persian Gulf and the efforts to develop a national energy strategy to foster energy independence from imported oil, SCS believes it would not be wise to dramatically reduce expenditures on fossil energy research and development.

¹ The operating companies of the Southern electric system are: Alabama Power Company, Georgia Power Company, Gulf Power Company, Mississippi Power Company and Savannah Electric and Power Company.

Due to declining domestic petroleum reserves and production and increased dependence on imported oil, the United States is vulnerable to another oil crisis. Presently, oil is the major source of transportation sector fuels and there are no available near-term alternatives. Less than five years ago, only 27 percent of the U.S. oil supply was imported. In early 1990, imported oil accounted for about 50 percent of domestic consumption and is expected to rise to 70 percent in the late 1990s. By the year 2000, imported oil costs will be an estimated \$200 billion annually. Importing oil on this scale adversely affects the U.S. trade deficit. In 1989, for example, imported oil and petroleum products accounted for \$48 billion, or over 40 percent, of the total U.S. trade deficit.

While the United States is deficient in oil reserves and production capability, it does have abundant resources of coal and oil shale that can be used to reduce dependence on imported oil and reduce the balance of payments deficit. Coal accounts for 80 percent of the recoverable fossil fuel reserves in the U.S. but supplies only 23 percent of the energy consumed. It is estimated that 625 billion barrels of liquid fuels can be produced from coal and oil shale, which far exceeds Saudi Arabia's present 166 billion barrels of reserves.

Due to low oil and gas prices and tighter environmental regulations, many energy consumers, including electric utilities, are switching back to oil or natural gas. Between 1990 and 2000, it is estimated that over 50,000 megawatts of combustion turbines or combined cycle capacity will be added that will require premium liquid or gaseous fuels. There is a need for coal based technologies that are compatible with combustion turbines to assure that capacity will be available when needed. These technologies must have high efficiency, low environmental emissions, and low capital cost.

Appropriately, therefore, the Administration's National Energy Strategy ("NES") asserts that the nation should attempt to benefit from its enormous, low-cost coal reserves. The Strategy also recognizes that a variety of efforts are necessary to reduce the cost, investment risks, and environmental impact of coal use. At the same time and contrary to the NES, the Department of Energy has submitted a budget for Fiscal Year 1992 that reduces fossil energy research and development by approximately sixty percent. Further, the budget authors do not explain or justify why such a drastic reduction or any reduction is warranted.

While SCS recognizes the need for national budget restraints and agrees that some reductions in funding may be desirable, we believe that a sixty percent reduction contradicts the Administration's stated intent to boost efforts to produce alternative fuels from coal and to broaden end use of the products of coal research and development. This proposed cut is particularly harsh in light of the concurrent recommendation to require a 50-50 cost-sharing requirement of research and development performers.

Cost Sharing Requirement for Fossil Fuel Research

The Department of Energy's proposed FY 1992 budget calls for an increase in percentage of private versus public cost sharing to a fifty-fifty match. Apparently, this requirement would apply to many fossil fuel research projects that are already under contract. As a company that has invested millions of dollars in helping develop technologies that will benefit the entire nation, we believe this level of cost sharing is too high. For large scale demonstration projects, such as the Innovative Clean Coal Initiative, with near term commercialization objectives, the 50% cost sharing requirement is somewhat reasonable. On the other hand, for longer term technology development, a 50% investment requirement may prove simply too large for many companies.

While many electric utilities are not small companies, they have traditionally been technology users, not technology owners. In general, electric utilities invest in technology for the benefit of their customers, not for their stockholders. Thus, electric utilities lack a mechanism to quantify the value of technology, therefore, it is difficult to justify investment to the stockholders. At the same time, we believe it is important that technology users, like utilities, participate in technology development to assure that it will be understood, accepted, and therefore, commercialized more quickly.

Promising Fossil Fuel Technologies

To illustrate how coal research can produce useful results, SCS would point to a number of promising coal technologies. For example, government sponsored research has been instrumental in helping develop gasification and pressurized combustion technologies. Both technologies can be used to repower existing coal fired power plants, to refuel combustion turbines, to reduce dependence on petroleum, or to add new base load capacity. Before they can be fully employed, however, additional development is necessary, particularly in gas stream cleanup. Nonetheless, these technologies can in the near future improve unit efficiency and reduce environmental harm associated with the use of coal.

Another developing technology is advanced coal cleaning, using agglomeration or flotation. It may provide industries and utilities with a process to produce low sulfur, compliance coal from medium sulfur coal. While it is possible to achieve high sulfur removal from some coals using existing technology, it is not currently possible to simultaneously achieve sulfur removal with high energy recovery. When perfected, this technology in the hands of fuel users will help increase the supply and limit future cost increases of low sulfur coal.

Coal liquefaction technology can be used to produce clean liquid fuels for transportation, for power generation, or as a chemical feed stock. Direct coal liquefaction can cap the price the United States pays for imported oil and can also help reduce the trade deficit. Significant improvements in the economics of coal-derived liquids have been made in recent years - for example, a 57 percent decrease in cost has been realized between 1983 and the present. The highest barrier for coal-derived liquids is the need to reduce production costs so that coal-derived liquids can economically compete with petroleum.

Many technologies discussed above can be integrated to obtain other less obvious benefits. For example, physical coal cleaning can be used for efficient inexpensive ash removal, coal gasification can be used for fuel gas and hydrogen production, pressurized combustion can be used for waste treatment, and coal liquefaction can be used for liquid fuel production. Another promising opportunity is the possible development of a large-scale energy refinery that can turn coal into a broad variety of energy forms, including electricity and liquid fuels.

Commercialization Status of Technologies

Coal Gasification and Pressurized Combustion:

For new base load power generation, coal gasification and pressurized combustion technologies offer potentially significant improvements in cost, efficiency, and environmental performance over conventional pulverized coal combustion. Conventional coal gasification combined cycle power generation with cold gas cleanup is technologically ready for commercialization. At this point, however, the economics do not justify general commercialization. The risks associated with this new technology simply do compare favorably to proven technology, such as a pulverized coal power plant. We believe, however, commercialization of cold gas cleanup will eventually occur because it offers facilities environmental advantages and fuel flexibility. Some believe that commercialization will occur between 1995 and 2000.

Hot-Gas cleanup and advanced integration cycles for coal gasification/pressurized combustion systems offers the potential for these systems to be clear winners on cost, efficiency, and environmental considerations. The technology is not as well developed as conventional systems and additional research is required. The technical feasibility of these improvements should be demonstrated between 1995 and 2000. The economic advantages should be demonstrable on a commercial scale between 2000 and 2005, with full commercialization between 2005 and 2010 based on present funding levels.

Coal Cleaning:

Advanced coal cleaning is a technology that may play a role in helping utilities meet emissions standards for sulfur and perhaps trace elements from existing power plants. It may also help control future price increases for low sulfur coal by increasing the supply of compliance coal. It is not, however, a generic, universally applicable technology for utilities. The technology is limited to coals with specific chemical and physical characteristics. The technology can be commercially available between 1994 and 2000. With the exception of a few sites, it will probably be applied as a secondary or supplemental control, rather than as a primary control strategy. The Electric Power Research Institute has recently made potential breakthroughs in understanding coal chemistry. These new discoveries may permit even higher removals of sulfur from coal, but the technical and economic advantages have not been completely developed. These improvements will probably not be demonstrated until after 2000.

Direct Coal Liquefaction:

Direct coal liquefaction is a technology that has been under development for a number of years and significant progress has been made in recent years in improving the efficiency and economics of the technology. Yields of liquid fuels have been increased to over 70% and the costs have been reduced to about \$35/barrel. Technologically, direct coal liquefaction is ready to move to the demonstration stage of development. Some progress continues to be made at the pilot scale but, without a breakthrough, these improvements will continue to be gradual. The principal reason that direct coal liquefaction has not been commercialized is the variability in world oil prices. Commercialization, without some form of federal subsidy or incentive, will probably not occur until after 2005.

SCS Work at the Wilsonville Project

At the Wilsonville Clean Coal Research Center, SCS is developing coal based technologies that address a broad range of key issues that face the electric utility and transportation industries today. Those projects are as follows:

Status Hot-Gas Cleanup:

The project provides for the design, construction, and operation of a joint industrial/DOE facility for engineering-scale testing and development of devices to remove particulates in high-efficiency coal gasification and pressurized fluidized bed combustion power plants. This form of particulate removal must be perfected in order to utilize new high-performance gas turbines in coal-based power plants with hot gas cleanup. When fully developed, the technology will improve the efficiency of power

generation from coal by over 1000 Btu/kwh, will lower the cost of electricity by over 10 percent, and will be more acceptable by coal-based utilities than today's combined cycle designs. The preliminary engineering has begun on the facility and detailed design should be completed by September, 1992. Construction of the facility should be finished by September, 1993, and a two year component testing phase will begin immediately after. The project is scheduled for completion by the end of FY 1995.

The Congress provided \$5 million in funding for the initiation of the hot-gas cleanup project in FY 1990. The total cost of the project is expected to be \$46 million over 5 years, of which 20 percent would be funded by industry in a cooperative agreement with the DOE. The Electric Power Research Institute has pledged support for the project goals and objectives. Southern Company Services, Inc., The M. W. Kellogg Company, together with the Electric Power Research Institute have committed to share 20 percent of the cost through the engineering phase of the project, which will cost approximately \$6 million.

Advanced Physical Coal Cleaning:

The purpose of the Advanced Physical Fine Coal Cleaning by Selective Agglomeration is to develop a process to remove 90 percent of the inorganic sulfur from typical eastern bituminous coals, recover 90 percent of energy content of the coal, and produce a physically stable product. Site preparation, detailed design, and construction of the component development facility are complete. Plant startup has begun. Operation and testing of the facility is scheduled for completion by fourth quarter of 1992. Through 1990, DOE has invested approximately \$4 million for this project and industry has contributed approximately \$1 million. Cost sharing for this project, which exceeds 20 percent, is provided by the Electric Power Research Institute, the Southern electric system, and the Alberta Research Council.

Direct Coal Liquefaction:

The purpose of the Wilsonville Advanced Coal Liquefaction R&D Facility is to reduce the cost of producing premium liquid fuels from coal. During the last year, Wilsonville demonstrated up to 75% distillate yield with Pittsburgh No. 8 seam coal from the Appalachian coal fields. In addition, high distillate yields from a wider range of western, subbituminous coals was demonstrated. Modifications to the plant allowed demonstration of improved product quality and lower boiling range fuels. In September, 1990, SCS signed a new three year contract with DOE for continued operation of the Wilsonville facility. From 1976 through 1990, DOE has invested approximately \$90 million of the total project cost of over \$135 million in coal liquefaction research at Wilsonville. During the three years of the new contract, DOE will contribute an additional \$28 million and industry will provide approximately \$2.7 million excluding land and facility use cost. Cost sharing for this project is provided by the Electric Power

Research Institute, Amoco Oil Corporation, and the Southern electric system. Between 1990 and 1993, this cost sharing will account for about 7 percent of the project costs. Since the project's inception, private sector cost sharing amounts to over 30 percent of project cost.

Conclusion

Great strides have been made in developing innovative coal use technologies. It is safe to say that this progress would not have been possible without the strong and consistent support of the Federal government has lent to research and development efforts. With so many possible direct and indirect benefits from the program on the horizon, SCS believes the Fossil Energy Research and Development Program is worthy of continued congressional support in its own right and as a part of a larger national energy strategy for the coming decade and beyond.

Mrs. LLOYD. Thank you very much, Mr. Styles.
Mr. Wisdom, please proceed.

**STATEMENT OF LAWRENCE I. WISDOM, VICE PRESIDENT,
HRI, INC.**

Mr. WISDOM. Madam Chairman, before I begin my testimony today, I would like to thank you and the members of the subcommittee for the opportunity to testify. With your permission, I will summarize my testimony and ask that the full statement be submitted.

Mrs. LLOYD. Without objection, both of you will have your complete statement inserted in the record.

Mr. WISDOM. Thank you.

Madam Chairman, over the last 30 years, Hydrocarbon Research, Inc. of Princeton, New Jersey has played a key role in the research and development of coal liquefaction. We believe that the continued support of Congress and the Department of Energy are and will be a key element of HRI's success in bringing this technology to commercialization.

The recent crisis in the Middle East is causing all of us to re-evaluate our priorities in regard to energy security. The President's National Energy Strategy Report confirms in part what we all have known—that this country's oil requirements are increasingly met by imports, and that those imports have risen to a level which is unacceptable.

One result of the unpredictable boom and bust cycles in the oil market is a reluctance on the part of the industry to rush into major drilling and other investment activity in response to oil price instability. We believe the Federal Government should support programs which provide the private sector some measure of confidence that their investments will not be held hostage to this unstable market. HRI believes that continued federal support for coal liquefaction research, development, investment, and commercialization is critical in the next three to five years to develop and maintain the balance of fuels which is necessary to our economy and national security.

In recent year, through the support of the United States Department of Energy, HRI has made significant advances in coal liquefaction by developing a new generation of technologies, which we call our Close-Coupled Two-Stage Liquefaction and Coal/Oil Co-Processing. Specifically, in the last several years, we have cut production costs while increasing the quality of these fuels. Liquid yields have increased by more than 50 percent towards a selectivity towards transportation fuels, and decreased sulfur contents to less than 0.01 percent.

Since 1983, DOE has spent almost \$12.5 million, with roughly \$630,000 from HRI in developing the CTSL technology. We are in the final stages at our research center in scaling-up this technology, and require additional funding of roughly \$2.5 million for the next three fiscal years. This will complete the program which we started in 1983 and provide a firm basis for commercial demonstration. Given the results achieved to date, HRI has indicated to the Department of Energy that it is prepared to cost-share this remain-

ing expenditure for the fiscal years. In parallel with this activity, HRI is also developing a commercial project and has found equity investors to demonstrate this technology at a scale of 1,500 tons per day of feed under the Clean Coal Round 4 program.

In regard to Coal/Oil Co-Processing Technology, this technology was an out growth of work that we did in the 1970s with private funding. It's basically a hybrid between the work that we had been doing on coal liquefaction and the work that the company has been doing on heavy oil upgrading. Recently, HRI developed a program with the Department of Energy, the Electric Power Research Institute and private industry from Canada, Germany, and Japan to move this technology along. Roughly, \$3 million has been spent on this program, which includes 30 percent of cost sharing from the private industry. Encouraging results from this program has led HRI and members of its consortium to request that DOE pursue this effort in order to improve economics further and meet new standards for transportation fuels currently envisioned under the Clean Air Act. Continued funding at the level of roughly \$1 million annually over the next three years, with a minimum of 30 percent cost-sharing is envisioned.

On the commercialization front, HRI is working with its current project sponsor, Ohio Clean Fuels, which was awarded a contract under the Clean Coal Round I Program.

On the economic side, I'd like to clear up a few misunderstandings that we have had recently in a number of publications in Washington. Specifically, it has been mentioned in the National Injury Report and other reports that for coal liquefaction to become economical today, you must be looking at prices in the range of \$35 to \$40 a barrel. That's true for what we call our CTSL process, but it is directly related to the products of that process.

As shown in my testimony, there is graph of distillate prices over the last ten years as well as imported crude oil in the last ten years. Imported crude oil typically runs \$4 to \$5 less than those product prices. So on a crude oil equivalent basis, direct liquefaction is really in the \$30 to \$35 range. In co-processing, on a crude oil basis, it's in the range of \$20 to \$25. So there has been much progress that has been on this front, from the \$70 per barrel we were estimating in the early 1980s to here we are today in the early 1990s of now looking in the range of \$20 to \$35 a barrel.

The hurdles to commercialization are difficult, due to the fact that this is a capital intensive type of industry, dealing with a very highly volatile oil price market. Consequently, financing becomes a key hurdle to overcome. HRI sincerely believes that the discipline of the private sector capital markets is the best way to deliver products efficiently and effectively to consumers and provide the most competitive basis for an economy.

We recognize that taxes do not fall within the jurisdiction of this committee, Madam Chairman, however, I do believe it is important that we emphasize that we need to ensure some level of stability to encourage investor confidence in energy investments. Last year the budget reconciliation package included investment tax credits which will support investor confidence in the ethanol production industry. We believe a comparable tax credit for a coal-derived liquid fuel is not only needed, but also represents an important ap-

proach to achieving the diversity of fuels envisioned by a balanced energy supply strategy.

Another mechanism to introduce stability in the marketplace has been suggested by some of the legislation recently introduced which would mandate certain classes of transportation fuels used, alternate fuels, in their fuel mix. Such a program would be very helpful, we believe, to provide stability in an end-use market for coal-derived liquid fuels.

HRI believes that our coal liquefaction technologies can be economically commercialized at oil prices in the range that I have previously mentioned. They should be exceeded during this coming decade. With the continued support in Fossil Energy R&D and the development of policies to mitigate the risk of highly volatile oil prices, a viable coal liquefaction industry can become a reality.

Madam Chairman, I would like to thank you and the committee staff for your continued support. I'd be happy to answer any of your questions.

[The prepared statement of Mr. Wisdom follows:]

United States House of Representatives
Subcommittee on Energy, Research and Development
House Science and Technology Committee

March 5, 1991

by

Lawrence I. Wisdom
Vice President
Hydrocarbon Research, Inc.

Madam Chairman, before I begin my testimony today, I would like to thank you and the Subcommittee for allowing HRI this opportunity to testify today on the key role of the federal government in supporting fossil energy research and development. With your permission, I will summarize my remarks and submit my full statement for the hearing record.

Madam Chairman, over the last thirty years, Hydrocarbon Research, Inc. of Princeton, New Jersey, has played a key role in the research and development of coal liquefaction; we believe that the continued support of Congress and the Department of Energy are and will be a key element of HRI's success in bringing this technology to commercialization.

The recent crisis in the middle east is causing all of us to re-evaluate our priorities in regard to energy security. The President's National Energy Strategy Report confirms in part what we all have known--that this country's oil requirements are increasingly met by imports, and that those imports have risen to a level which is unacceptable.

One result of the unpredictable boom and bust cycles of the oil market is a reluctance on the part of the oil industry to rush into major drilling and other investment activity in response to oil price instability. We believe the federal government should support programs which provide the private sector some measure of confidence that their

investments will not be held hostage to this unstable market. HRI believes that continued federal support for coal liquefaction research, development, investment and commercialization is critical in the next three to five years to develop and maintain the balance of fuels which is necessary to our economy and national security.

The production of liquid fuels from coal became a reality in 1979 with the opening of the largest coal liquefaction plant in the United States. This plant, located in Catlettsburg, Kentucky, demonstrated HRI's H-Coal® Process for converting 600 tons of coal per day into 1,800 barrels of liquid fuels. Funding for this project came from the Department of Energy, the Commonwealth of Kentucky and private industry. Demonstration operations were highly successful and ran for three years. The heart of this process is the ebullated-bed reactor which HRI invented in the early 1950s. The first commercial plant using this novel reactor system came on stream in 1968 in which heavy oil was converted into clean transportation fuels. Since 1968 a number of commercial plants have been built around the world for processing heavy crude.

In recent years, through the support of the United States Department of Energy, HRI has made significant advances in coal liquefaction by developing a new generation of technologies, which we call our Close-Coupled Two-Stage Liquefaction of Coal (CTSL™) Technology and Coal/Oil Co-Processing Technology. Specifically, the following breakthroughs have been made which have drastically cut the production costs and increased the quality of the liquid fuel product:

- Increased Liquid Yield by 50%
- Increased Selectivity to Gasoline & Diesel
- Decreased Sulfur content to 0.01 wt%

CTSL TECHNOLOGY

The CTSL Technology is an outgrowth of the H-Coal Process and consists of two ebullated-bed reactors in series. Since 1983 DOE has spent approximately \$12.5 million and HRI \$630 thousand dollars in developing this technology. HRI's CTSL Technology is in the final stages of scale-up, under DOE Contract No. DE-AC22-88PC88818, and requires add-on funding at the level of \$2.4 million for fiscal years 1992, 1993 and 1994. This will complete the program which started in 1983 and provide a firm basis for commercial demonstration. Given the results achieved to date, HRI has indicated to DOE that it is prepared to cost share this expenditure for the coming fiscal years. In parallel with this activity, HRI is developing a commercial project to demonstrate this technology at a scale of 1,500 tons per day of feed.

COAL/OIL CO-PROCESSING TECHNOLOGY

HRI's Co-Processing Technology is a hybrid of the H-Coal Process (i.e., coal liquefaction) and H-Oil Process (i.e., heavy oil upgrading). In the mid 1970s HRI experimented with the co-processing of coal and residue derived from petroleum. Encouraging results led us to develop this concept further which highlighted three distinguishing features over direct liquefaction: (1) synergism between the feedstocks which lowered operating costs, (2) ability to build a smaller plant with reasonable economics and (3) capable of integrating with existing refineries. After spending several million dollars of private funds, HRI entered into a contract with the Department of Energy, EPRI and private industry in Canada, Germany and Japan in 1987. This \$2.9 million dollar program includes 30% cost sharing from private industry. Encouraging results from this program has led HRI and members of its consortium to request that DOE pursue this effort in order to improve economics further and meet new standards for transportation fuels currently envisioned under the Clean Air Act. Continued funding at a level of \$1 million annually over the next three years, with a minimum of \$250 thousand annually in contribution from the

private sector, will lay a solid foundation for commercializing this important technology. In parallel with this research program, HRI is working hard to commercialize this technology through the Ohio Clean Fuels Project, which was awarded a contract under Clean Coal Round I.

ECONOMICS

Great progress has been made in reducing the cost of liquid fuels from coal. The estimated cost of liquids for a commercial coal liquefaction plant was recently estimated by EPRI⁽¹⁾ to be \$72 per barrel for the H-Coal® Process. In the last eight years we have been able to reduce this cost to \$24/bbl - \$40/bbl for the Co-Processing and CTSL technologies. These product costs (i.e., gasoline, diesel and turbine fuel) equate to crude oil prices in the range of \$20 to \$36 per barrel. As shown in *Figure 1*, Coal Liquefaction is close to becoming economically attractive. A summary of the cost of producing transportation fuels from coal is presented below:

	CO-PROCESSING		CTSL PROCESS
	<u>Refinery</u> (\$/bbl)	<u>Grass roots</u> (\$/bbl)	<u>Grass roots</u> (\$/bbl)
Investment	8.50	11.50	16.50
Operating Cost			
- feedstock	8.00	8.00	2.50
- variable	3.00	3.00	10.00
- fixed	<u>4.50</u>	<u>6.00</u>	<u>11.00</u>
Total Product Cost	24.00	28.50	40.00

COMMERCIALIZATION HURDLES

Commercialization of coal liquefaction technologies is made difficult due to the fact that it is capital intensive in a highly volatile oil price market. Consequently, financing becomes

⁽¹⁾ Basu, A., Masin, J.G., Steward, N.C., "Improvements in the Cost of Liquid Fuels from Direct Coal Liquefaction," presented at 7th Annual International Pittsburgh Coal Conference, Sept. 10-14, 1990.

a key hurdle to overcome. HRI believes that the discipline of the private sector capital markets is the best way to deliver products efficiently and effectively to consumers and provide the most competitive basis for an economy.

We recognize that taxes do not fall within the jurisdiction of this Committee, Madam Chairman, however, I believe it is important that we emphasize the importance of ensuring some level of stability to encourage investor confidence in energy investments. Last year the budget reconciliation package included an investment tax credit which will support investor confidence in the ethanol production industry. We believe a comparable tax credit for a coal-derived liquid fuel is not only needed but also represents an important approach to achieving the diversity of fuels envisioned by a balanced energy supply strategy.

Another mechanism to introduce stability in the marketplace has been suggested by some of the legislation recently introduced which would mandate certain classes of transportation vehicles use "alternate fuels" in their fuel mix. Such a program would be very helpful, we believe, to provide stability in an end-use market for coal-derived liquid fuels. We would like to stress that coal-derived liquid fuels should be included in the definition of "alternate fuels" of any legislation of this type. Preliminary economics performed by HRI indicate that we could successfully finance 10,000 to 20,000 barrels per day of product from a coal liquefaction facility if the gasoline, diesel and utility fuels carried the same sort of tax treatment as the ethanol producers for the transportation fuel market.

GLOBAL WARMING

Emissions of greenhouse gases, most notably carbon dioxide from electric power generation and transportation fuels, and their impact on global climate has emerged as a

major national issue in the last several years. In a recent report⁽²⁾ issued by the National Research Council on "Confronting Climate Change: Strategies by Energy Research and Development", a major finding from this study is to increase energy productivity through improvements in the efficiency of energy use and conversion technologies. In the last eight years, HRI has increased the liquid yields from 3 barrels to 5 barrels per MAF ton of coal. This increase has substantially reduced the amount of carbon dioxide emissions per barrel of fuels produced. Current investigations underway include combined cycle power generation to add further significant improvements in thermal efficiency of these technologies.

CLEAN AIR ACT

Fuels produced from coal liquefaction are shown in *Table 1*. Further upgrading of these fuels are planned in the upcoming program with DOE to ensure that all of the new requirements are met or exceeded. Preliminary work already completed under our DOE program with on-line hydrotreating showed promising results for our CTSL Process.

The effectiveness of on-line hydrotreating of CTSL coal-derived distillates in reducing nitrogen, sulfur and aromatics was recently demonstrated on New Mexico and Wyoming coals. Nitrogen and sulfur levels of the light distillate naphtha fraction (180-390°F) were reduced to less than 10 parts per million. This crystal clear, water white fuel had an aromatics content of less than 10%, well below the criteria established by the Clean Air Act.

⁽²⁾ Committee on Alternative Energy Research and Development Strategies, National Research Council, "Confronting Climate Change: Strategies for Energy Research and Development," National Academy Press, 1990

WHAT WILL THE FUTURE BRING?

In general, I think we can anticipate a growing dependence on imported oil, greater environmental concerns in developing oil reserves at home and a fluctuating oil price. The uncertainties of our future need to be dealt with in a broad-based national energy plan. Part of this plan should deal with the reduction of imported oil through the development of a coal liquefaction industry.

A 200,000 barrel per day coal liquefaction industry would provide a market for 15 million tons per year of high sulfur coal. Today more than 100,000 people work in 4,000 U.S. mines producing a commodity valued at more than \$20 billion per year. This new industry will ensure that the U.S. can continue using its most abundant energy resource, while maintaining a commitment to a clean, healthy environment and a strengthening economy.

In closing, I wish to quote from Interior Secretary Manuel Lujan, Jr.:

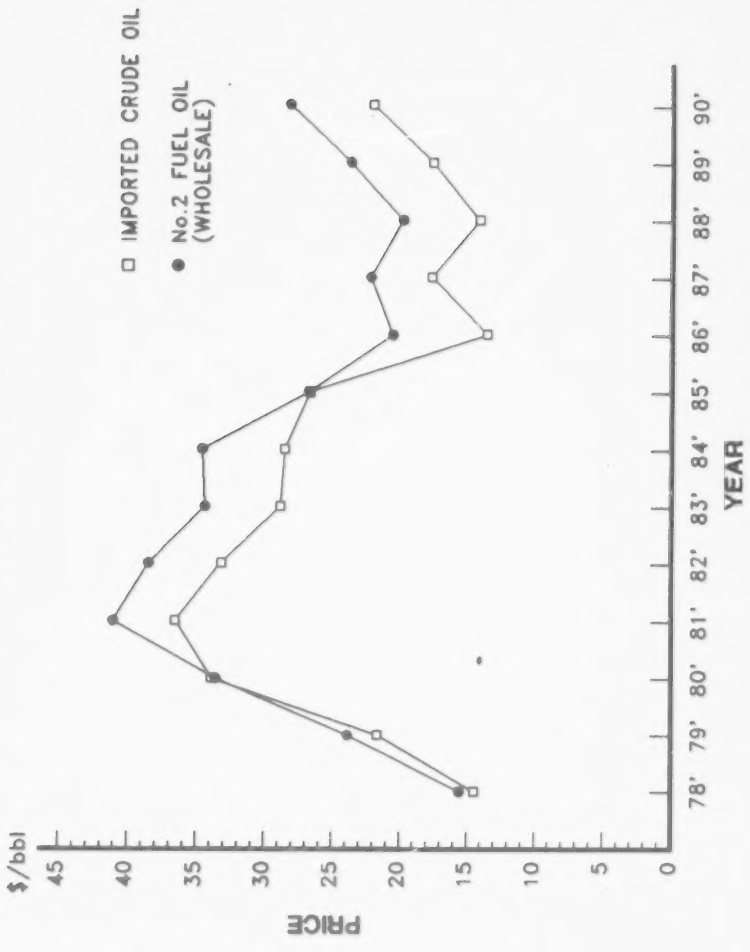
"When we move in the direction of shutting down American development, when we base policy on limiting our potential rather than expanding it, when we turn to foreign lands to supply our energy needs - then I can't help but feel that somewhere along the way we've surrendered something of our freedom - and relinquished our independence."

HRI believes that our coal liquefaction technologies can be economically commercialized at oil prices of \$24 per barrel, prices that will be exceeded during this decade. With the continued support in Fossil Energy R & D and the development of policies to mitigate the risk of highly volatile oil prices, a viable coal liquefaction industry can become a reality.

Madam Chairman, I would like to thank you, the Committee and the staff for your continued support. The continued support from Congress and the Administration will ensure the continued development of a technology that can provide environmentally clean transportation and utility fuels from a strategic domestic resource.

I would be pleased to answer any questions that you or other members of the Subcommittee might have.

CRUDE and DISTILLATE PRICES 1978 - 1990



SOURCE: OIL & GAS JOURNAL, January 28, 1991

TABLE 1

TYPICAL CTSL PRODUCT QUALITIES

<u>IBP/350°F Naphtha</u>	<u>Illinois Bituminous</u>	<u>Wyoming Sub bituminous</u>
API	47	49
S,W%	.01	.01
N,W%	.24	.05
P	16	18
O	6	6
N	68	69
A	10	7
<u>350/650°F Distillate</u>		
API	22	28
S,W%	.01	.01
N,W%	.31	.11
P	14	7
O	7	5
N	25	43
A	54	45
Cetane Number	-	33

Mrs. LLOYD. Thank you, Mr. Wisdom.

Mr. MORRISON.

Mr. MORRISON. What form of affluence results from the burning of these liquefied coal products, either one of you, please.

Mr. WISDOM. There is a range of coal products from the plan, starting with your light distillate fuels, moving down to the bottom end.

Mr. MORRISON. Perhaps in comparison with, say, ethanol, since you brought that issue up in the tax advantage that is provided.

Mr. WISDOM. Our current program has been aimed in terms of meeting the specifications in the Clean Air Act, specifically so that the gasoline or diesel that is produced from these plants could be blended in with petroleum gasoline and diesel, and take advantage of the available infrastructure for distribution of those products. They would have similar performance, as you would expect with some of the petroleum fractions in that range. A measure in diesel is what they call a "c-tain" number, which is an engine test number. It gives you a feeling of performance. Work that we've done recently shows that the sulfur specifications envisioned by the Clean Air Act.

In regard to the unconverted bottoms, which is the unconverted coal and ash in some of the residual oil, there are a number of dispositions for that material. One is with feeding to a partial oxidation gasifier, like the Texaco gasifier that has been demonstrated on the Cool Water Project in California. Another could be fed into an existing delayed coker, or depending upon the sulfur content, fed into a conventional boiler.

Mr. MORRISON. You mentioned the tax incentives and some of the other advantages that other alternative fuels have and you would like to have those also, which is understandable. I guess part of the driving force there was that, you know, it's an agricultural product and, of course, supposedly better for the environment. You're saying you can meet, fundamentally, those same standards.

Mr. WISDOM. From the recent reports I've read from the OTA, which has talked about the energy use for the production, conversion, and distribution of those alcohol products to market, one would have to look at the total fuel consumed to the fuel you actually produced, in looking at that. There is no doubt, if you take a look at a petroleum, gasoline, or diesel, or a coal-derived gasoline or diesel that it would product greater carbon dioxide than an ethanol fuel. I think if you start at the very beginning in terms of where its produced and go all the way to the end result in combustion, I don't think those differences are as large.

Mr. MORRISON. So you are saying the tractor you have to drive to produce the agricultural products to produce the energy, you know, that scenario, the full picture, in fact, you come out fairly even.

Mr. WISDOM. You come out certainly very close. I think the key point that was made earlier by the Assistant Secretary, I think, is a key one for everybody and the committee to pay heed to. I think one of the keys that we have to do in the U.S. today is push all of our technology options to higher efficiencies. That certainly will bring us a long way to reducing emissions. I'm not promoting today one fuel over the other. I think all fuel forms could use a degree of higher efficiency to everyone's benefit.

Mr. MORRISON. Madam Chairman, I guess occasionally during these hearings, I kind of paused to write myself a mental note. I think maybe today's hearing has brought out something. We have to be a little bit careful of some of our new forms of energy. They sound great, but they probably cost as much in creating them as they provide benefits.

Mrs. LLOYD. And the cost of energy to produce them.

Mr. MORRISON. That's right.

Mrs. LLOYD. Your point is well taken, Mr. Morrison.

Mr. MORRISON. Just one other question, perhaps, Mr. Styles, for you. Mr. Wisdom spoke quite a bit about cost. I noticed that Wilsonville is continued. That's direct liquefaction.

Mr. STYLES. That's correct.

Mr. MORRISON. Could you compare that with indirect. I know the subcommittee has wrestled periodically with the different technologies, and its relationship with cost on down the road.

Mr. STYLES. I think both technologies have a place. Indirect liquefaction may be best suited for producing methanol and a segment of the transportation fuels, whereas, direct coal liquefaction can produce a broader range of products than the indirect can, can produce it more efficiently than indirect liquefaction can. As a utility, we're very interested in indirect liquefaction as an opportunity to co-produce chemicals while we generate electricity using gasification. I think economically, they are very similar today, based on studies that the Electric Power Research Institute has done.

Mr. MORRISON. So with direct you get a variety of products. How many of those would be related to, say something you would burn for energy purposes as a utility?

Mr. STYLES. One of the co-sponsors of our work at Wilsonville is Amoco Corporation. They are very interested in direct coal liquefaction to produce transportation fuels. Our project has been primarily tailored to maximize transportation fuels. Roughly 30 percent of our fuels might be in the utility range product.

Mr. MORRISON. Thank you. Thank you, Madam Chairman.

Mrs. LLOYD. Thank you, Mr. Morrison, Mr. Fawell.

Mr. FAWELL. I have no questions.

Mrs. LLOYD. Mr. Styles, what do you see, and I'm going to ask you the same question, Mr. Wisdom, so you can both answer this question, what do you see as the role of coal in our energy mix and our overall national energy plan, near term and long term. I'm especially interested in near term.

Mr. STYLES. In near term, I think we have to rely heavily on coal because it is one of our largest domestic resources. I think as the previous speakers have said, and I agree, we should look for ways to improve the efficiency and the environmental cleanliness in which we use coal. Those are the directions that the research is heading. I think we should depend very heavily on coal in the future.

Mrs. LLOYD. Well, 20, 30?

Mr. STYLES. Over 50 percent.

Mrs. LLOYD. For coal, 50 percent of our energy production. Mr. Wisdom.

Mr. WISDOM. Well, I would support Mr. Styles comments. I mean, it's our largest domestic resource that we can turn to, and it's a

resource that we have been working very hard to make it a very useful resource in the electric power generation industry. I say it's a resource that could be equally applied in the petroleum industry, but in the longer term.

Mrs. LLOYD. Yes. I think I may have a different perspective of cost sharing. I think there is some technologies the Federal Government has no business funding. I think there are other industries that if the Federal Government is a reliable partner, they should be cost-shared. I also believe that there are technologies where there is a specific role for the Federal Government, with long term investments where it benefits the economy, where it benefits not only the American population, but our world population. This, indeed, is the role for the Federal Government. Where do you think the private sector should predominantly be involved in cost-sharing, in the research phase? What stage of development do you think there is a greater role to cost-share?

Mr. STYLES. I think for our company, because we have not traditionally been technology developers, it is much easier for us to justify participation in demonstration projects. It gives us opportunities to get hands-on technology and implement it quicker. In technologies that are 15 years out, it is very difficult for us to justify internally large investments from those technologies.

Mrs. LLOYD. At what stage in the technology do you think federal funds should be withdrawn?

Mr. WISDOM. I would say that no doubt after the demonstration of a project, for instance, after the Clean Coal Program, where you're building really a prototype program of a commercial size. That should be the point where that technology is fully demonstrated to the satisfaction certainly of the private sector at a minimum to enable them to carry the ball forward. At HRI, where our focus has been, and continues to be commercialization, we typically apply a rule that the closer you are to commercialization, the larger you can justify to your stockholders to put more money into the kitty, so to speak, for cost-sharing. The longer term the research is, the more difficult it is to justify any significant amount of cost-sharing.

Mrs. LLOYD. Use of federal funds. Mr. Wisdom, I know that you're a partner in a \$2.9 million program to develop HRI's co-processing technology, is that correct?

Mr. WISDOM. That's correct.

Mrs. LLOYD. You indicated there are three partners in your agreement. I don't want to get into your proprietary information, but how does this work in terms of owning a technology and these related issues with an international partner?

Mr. WISDOM. It really works quite well. HRI basically takes the lead role in the consortia. What we've done is we've structured this in such a way that we've told the private participants that really for a modest investment, they are getting a tremendous amount of data and research back for it, because of the leveraging aspects. Most of the private participants are participating because they have co-reserves of their own in their country that they are trying to develop. They are trying to get a better understanding of how this technology could possibly be applied to their reserves back home. By participating in the program, they can get a more in

depth understanding of the technology and a better appreciation of how it can be applied to their particular situation.

Mrs. LLOYD. You said that coal liquefaction technologies can be economically commercialized at \$24 a barrel. What research and development needs to be done to bring the price of coal based liquids down?

Mr. WISDOM. The current effort that we have in coal processing today for our next three year program is emphasized in two areas. One is to make further refinements in our reductions of cost, and we're looking in the range of \$5 a barrel in terms of reduction. The second key component is being able to insure that the liquid products will meet all the new Clean Air Standards that was enacted last year. That's our primary emphasis.

Mrs. LLOYD. At \$24 a barrel, how much will it cost you to produce this barrel of oil.

Mr. WISDOM. The \$24 per barrel includes the investment in operating costs and a 15 percent return to the investors. The problem that we have with the investors is that last year oil prices bottomed out at \$15 a barrel.

Mrs. LLOYD. Are we talking about \$50 a barrel or \$100 a barrel, to produce a \$24 barrel of oil?

Mr. WISDOM. It costs the investors, with a return on their investment, \$24 to produce that barrel of produce. That produce is composed of one-third gasoline and two-thirds, what we call a number two turban-type fuel. Those are the two primary components. Now today, this morning, when I got up, I think light crude prices were trading at roughly \$20 a barrel today. So you can see, in today's climate, we have some months where we're above that threshold, but other months we're below that threshold. The question is, either getting the price low enough so the investors can take that risk and the volatility of the market, or to have some sort of measures or policies implement that would provide some risk assurance to the investors.

Mrs. LLOYD. Mr. Styles, the Department of Energy has, and I know you're very thankful, requested funding for Wilsonville this year. It was contingent upon 50 percent cost-sharing. Do you plan to cost-share your activities?

Mr. STYLES. No, we could not justify that. We're participating in coal liquefaction primarily as a national service. Less than 1 percent of our total generating capacity is dependent upon premium fuels such as petroleum or natural gas. While we are going to increase our dependence on premium fuels through 1995.

Mrs. LLOYD. Were you surprised?

Mr. STYLES. Surprised about 50 percent?

Mrs. LLOYD. The cost-sharing.

Mr. STYLES. Yes.

Mrs. LLOYD. What are you going to do if it is contingent upon receiving 50 percent cost-sharing.

Mr. STYLES. I don't think we have any alternatives. We will try to find other participants in our program. Amaco and the Electric Power Research Institute are primarily the largest cost-sharing participants at this time. EPRI's budget is very tight for the next several years. We don't see any reasonable opportunity of getting

more money from them. We're not aware of any other companies that are willing to participate at this time.

Mrs. LLOYD. Thank you very much. Thank you, gentlemen, for your excellent testimony. Our next witness is Mr. Donald Peoples, representing the Montana Technology Company and the development of MHD technology. Mr. Peebles, would you please proceed.

STATEMENT OF DONALD R. PEOPLES, MONTANA TECHNOLOGY COMPANIES, INC.

Mr. PEOPLES. Thank you very much, Madam Chairman, and Members of the Committee. It's a pleasure for me to be here today to speak to you regarding the fossil energy program. Madam Chairman, first of all, I would like to commend you for your statements about MHD. As you well know, the MHD activities that are taking place in your state have produced some very substantial results, in this last year, in some 2000 hours of testing.

Mrs. LLOYD. I would like to not sound too parochial, Mr. Peoples. I must reflect, for the record, that it is not in my district. You may proceed.

Mr. PEOPLES. In your state, okay, in your state, but it has been very significant. Let me just illuminate the other members of the committee. Using high sulfur, eastern coal, the coal-fired flow facility at the University of Tennessee Space Institute, in your state, Madam Chairman, has removed 99.5 percent of SOX without external equipment such as scrubbers. It has also been very significant in reducing emissions below the EPA's NSPS standards in the 1991 Clean Air Act by one-third. In addition, because of its high efficiency, the magneto-hydrodynamics process is also able to reduce the environmental concerns of global warming by reducing about half of the CO₂ output. So I think that is very significant.

Also, Madam Chairman and members of the committee, I would also like to comment on Secretary Gentile's comments. I feel that Secretary Gentile's comments, frankly, were very positive about MHD. I think the budget reflects more of OMB's position, and not Secretary Gentile's position. But nonetheless, we're appreciative of his comments, his positive comments, about MHD.

The war in the Middle East may be over, but it's no reason for us to go back to the old ways. Saddam Hussein may be on his way out, but frankly the political situation in the Middle East is going to remain unstable. We, of course, can delude ourselves that risks are acceptable when we have \$18 a barrel oil. But, we need to make sure that we are never again forced to fight to protect our energy supply.

It is interesting to note that both the National Energy Security Act and the National Energy Strategy both contain some very commendable aspects. But, it's disappointing, at least to me, that the National Environmental Strategy gives little priority to developing coal which, frankly, is the nation's most abundant resource.

On the other hand, DOE, and I guess more accurately, OMB's budget frankly has nothing to be commendable. A 51 percent cut in the fossil energy program at any time, in my view, is a bad idea. We have to look at advanced oil recovery technologies, fusion, nuclear power, renewable energy, conservation, and all technologies

as being essential and should be pursued by our national energy policies.

But we have to recognize that fossil energy is the nation's basic fuel, and will remain so for the foreseeable future. Comments made by previous speakers that the mix of energy coming coal is going to remain in the 50 percent plus area. I guess there is the argument that coal is incompatible with the environment. Frankly, members of the committee, that ignores the fact that the nation that produced the Patriot Missile has the ability to develop efficient and environmentally safe coal technology. We simply have to look at reducing our dependency on foreign oil. Fossil energy deserves a very high priority. Research and development that's closest to demonstration should certainly be accelerated.

Neither should we confuse the Clean Coal Technology Program with fossil energy R&D. The Clean Coal Technology Program focuses on commercialization, while R&D seeks new, untried technologies. Thanks to government R&D, there are highly efficient, environmentally clean, advanced coal technologies. Magnetohydrodynamics, or MHD, certainly is one of those.

I certainly don't need to go into any technical explanation of MHD, because I think you all probably have heard that explanation before. But work done at the University of Tennessee certainly proves that we can utilize coal to produce electricity in this country without suffering the environmental effects that we have experienced in the past.

Certainly a corollary to what's happening at the University of Tennessee is what is happening in Butte, Montana at the Department of Energy and Industries. I note that this is a cost-sharing program, a facility at Butte called the "proof of concept". This is located in Butte, Montana, and frankly, members of the committee, I know you'll be delighted to find that the program is on schedule. The channel, the combustor, and the final design are now being prepared. After construction, which is scheduled in 1992, we will begin shake down of that piece of equipment, the shale and the combustor, and we'll be entering into 2,000 hours of testing. This will be the longest test on a single channel using coal. No one can predict what the outcome of that is going to be. My scientists, frankly, are very confident. They are comfortable that we are going to succeed. They'd feel a lot more comfortable if we had additional spare channel parts and other equipment. That, through budget decisions in the past, particularly from OMB, have provided that funding to be cut so that we don't have a back-up channel and back-up components and oxygen systems that, frankly, would be desirable for continuous funding.

What's going to happen in Montana after the proof of concept concludes in 1993. I can tell you that we're very busy in Montana, putting together the next phase. That is a Clean Coal Technology 5 Program. We're planning to submit an application for Clean Coal 5 and Clean Coal 5's application is being put together by some industrial components consisting of The Montana Power Company, Westinghouse, Babcock & Wilcox, Gilbert Commonwealth, Avoco, TRW, and Montana Technologies. We plan to submit for Clean Coal 5. We are now also before the Montana State Legislature seeking funds for state participation in this process. The State of Montana

is considering it and, in fact, a hearing will be held on Friday morning of this week for \$50 million of state participation in the Magnetohydrodynamics Program for a partial match of Clean Coal Technology 5. We're excited about that. Frankly, I'm confident that the Montana State Legislature is going to see the wisdom of that proposal and approve a program that creates, for the first time, a Clean Coal Technology Program in the State of Montana. We're delighted with that.

Frankly, when I'm looking at, where we are in regard to the Fossil Energy Program of this country, I guess in the Magneto-hydrodynamics Program, I'm somewhat taken by a letter of Paul to somebody in the New Testament when he talks about fighting the good fight and running the good race. Well, in this case, I think we're at the point where we have been running the good race for a number of years. We've had a lot of good support. We don't want to stop 10 yards before the finish line. That's where we are, frankly, with the MHD Program. We're close, some \$680 million, as you pointed out, Madam Chairman, has been spent for MHD development through the Fossil Energy R&D Program. Frankly, we're close to the end. Another \$70 and, frankly, we're there. We're very excited about that and, again, we're very confident.

I guess in conclusion, Madam Chairman and members of the committee, let me recommend the following to you. First of all, I recommend that Clean Coal Technology go forward with Round 5 and Round 6 and, if necessary, Round 7. Under no circumstance, would Clean Coal Technology Funds be transferred to the Fossil Energy R&D. I think that would be disastrous to our efforts and the efforts of other very, very important R&D programs in this country. Thirdly, I suggest and submit that you adopt a three year authorization. That is extremely important to anyone in this business. We cannot be in a position of having the rug pulled out from underneath our feet. Within a three year period, as my fourth recommendation, I would recommend that one billion dollars be budgeted or authorized and appropriated for fossil energy development in this country. Frankly, we need a more balanced program. We need to take into proper perspective our domestic fossil energy resources in this country. Madam Chairman, I appreciate the opportunity to come and speak to you today about the MHD Program and about Fossil Energy Program. I would be pleased to entertain any questions that you or members of the committee might have at this time.

[The prepared statement of Mr. Peoples follows:]

Testimony of
Donald R. Peoples
President and Chief Executive Officer
Montana Technology Companies, Inc.
220 N. Alaska Street
Butte, Montana 59701

to

The Subcommittee on Energy Research and Development
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, D.C. 20515

March 5, 1991

The war in the middle east is over but this is not a reason to go back to our old ways of relying on foreign oil to fuel our economy. Saddam Hussein may be on his way out, but the majority of nations in that part of the world are ruled by absolute monarchs and dictators and the region's political instability offers little hope of improving in the foreseeable future. We can, of course, delude ourselves that risks are acceptable when the price of imported oil is \$18.00 a barrel. But, we also must be willing to ignore the costs of protecting that oil. In my judgement, it is time, while the discounted price is \$18.00, to take aggressive measures to ensure that the nation will never again be forced into fighting a foreign war to protect our energy supply.

Although both the National Energy Security Act of 1991 (NESA) and the National Energy Strategy (NES) have much to commend, it is disappointing that the NES gives so little priority to developing coal, the nation's most abundant resource.

On the other hand, DOE's - perhaps more accurately OMB's - fossil energy budget has nothing to commend. Even under normal circumstances a 51% cut in the R&D budget for the nation's most abundant, secure fuel source is a bad idea. For DOE/OMB to recommend such a cut when a war to protect foreign oil supplies has just been fought is most unfortunate.

Fusion, renewable energy, conservation, nuclear power in which people will have confidence, high energy physics and other technologies are essential to a long range energy policy and must be pursued. Nonetheless, the policy must recognize that fossil energy is the nation's basic fuel and will remain so for the foreseeable future.

The argument that coal is incompatible with the environment ignores the fact that a nation that can produce Patriot Missile Systems has the ability to develop efficient, environmentally safe coal technologies.

To reverse the nation's growing dependence on imported oil, fossil energy must be given the highest priority. Fuel cells, fluidized beds, advanced combustors, synfuels, coal preparation, cleaning advanced gas and oil recovery systems and other technologies should be brought into use as quickly as possible. R&D projects closest to demonstration should be accelerated. Government policies are needed to encourage defense industries to apply to energy technologies the expertise that produced the weapons used so successfully during the past several weeks.

Neither should we confuse the Clean Coal Technology (CCT) Program, with fossil energy R&D. CCT focuses on commercializing available technologies while R&D seeks new, untried technologies to meet future energy requirements. R&D has added payoffs in fall-outs that help to maintain the U.S. technological superiority and to open new worldwide market opportunities. MHD is an excellent example of technological fall-out. It came directly from early missile and space R&D. In turn, it gave birth to stabilized superconducting materials, advanced combustors and new methods of making glass, destroying hazardous waste and reducing iron ore.

Thanks to government R&D programs, for which the congress deserves praise, there are highly efficient, environmentally clean advanced coal technologies. MHD is an excellent example, as demonstrated by work done at DOE's MHD Coal Fired Flow Facility (CFFF) located at the University of Tennessee's Space Institute.

Using high sulphur eastern coal, the MHD unit removed 99.5 percent of SOx without external equipment such as scrubbers which can cause secondary environmental damage through residual contaminated land fills. The CFFF's NOx emissions were reduced to only one third of that allowed by EPA's NSPS and the 1991 Clean Air Act. If MHD generators were adopted by all U.S. power plants, these atmospheric hazards would be virtually eliminated. Because of its exceptionally high operating efficiency, MHD will reduce by half the CO2 output from coal fired plants. CO2 is considered by many authorities to be a cause of global warming. Best of all, in terms of achieving domestic energy independence, MHD power units can achieve these environmental advantages with all grades of eastern and western coal.

MHD is the acronym for magnetohydrodynamics, which translates into: "the interaction of a high temperature gas, that conducts electrical current, with a magnetic field." Scientists call gases with these properties "plasmas". When the process is used to generate electric power, coal is burned in a specially designed combustor to produce a 4500 F plasma. The plasma exits the

combustor into an MHD channel where it cuts through a magnetic field to produce electric energy. In a commercial plant this field will be produced by a superconducting magnet. The MHD process eliminates the turbines and rotating equipment essential to conventional power plants and marks the first major advance in base load energy conversion since the last century.

I am pleased to be able to report to you that the DOE/Industry Proof of Concept (POC) program is on schedule for completion in September 1993. The channel and combustor are in their final design stages. Construction will begin this year and the units will be completed and delivered to the DOE's Component Development and Integration Facility (CDIF) in Butte, Montana in 1992. After installation and shake down tests, the 2000 hour test will begin in early 1993. Completion of this test late that year will conclude the DOE POC program. Various modifications to the CDIF needed for the long duration test are continuing. The test will mark the longest power run at the CDIF or any other MHD test facility on a single channel using coal. New ground will be broken and happy and unhappy surprises may occur. No one can predict the outcome of a critical test in any technology development. We are confident that the test will prove satisfactory although my engineers and scientists would feel more comfortable if spare channel parts and other components were available. If DOE had provided the funding on the schedule called for in the POC, we would have had back up components for the power train and the oxygen system needed for continuous operation. Component stress would have been considerably lessened and the already tight schedule eased.

Progress at the CFFF, mentioned earlier, was exceptionally good this year. University of Tennessee scientists and engineers completed 2000 test hours using eastern coal and they are about to begin an identical test using western coal. The facility is responsible for characterization of coal as an MHD fuel, MHD environmental tests and the interface between the MHD topping cycle and the steam turbine bottoming cycle. Instrumentation development and testing at Mississippi State University continues on schedule. Superconducting magnets are available for use in an MHD generator without further development. Industry continues to meet it's cost share obligations in spite of OMB's efforts to terminate the program. As I will discuss below, industry continues to support the MHD technology and expects to propose a clean coal technology program upon completion of the POC.

To finish the POC and end DOE's development participation on schedule in 1993, I urge the subcommittee to authorize \$45 million for FY-92 and \$30 million for FY-93. I realize this is above the amount recommended in this year's appropriation. It will, however, provide insurance to handle unanticipated problems and finish the engineering development so that we can get on with the demonstration phase in 1993.

The demonstration phase calls for constructing an MHD unit and retrofitting it to an electric utility power plant to gain commercial operating experience. Preliminary designs for two MHD retrofit units have been completed by Westinghouse and the MHD Development Corporation (MDC). The Westinghouse design is for a generating station at Snead, Florida owned by Gulf Power Company, a subsidiary of The Southern Company. The MDC design is for a power plant at Billings, Montana owned by the Montana Power Corporation.

The Montana project is estimated to cost \$300 million. The MHD Development Corporation, of which I am a director, was organized by The Montana Power Corporation, Westinghouse, Babcock & Wilcox, TRW, Gilbert Commonwealth, Avco/Textron, Montana General Dynamics, and Montana Technology Companies, Inc. MDC is planning to submit a Clean Coal V proposal to retrofit the Billings plant and is conducting a major effort to assemble the required financial package. Legislation to provide \$50 million of the cost share is expected to pass the Montana Legislature in the current session.

In conclusion, I recommend to the Subcommittee that the Clean Coal Technology program go forward with Rounds V, VI and if necessary Round VII. 2. Under no circumstances should Clean Coal Technology funds be transferred to Fossil Energy R&D. 3. Adopt three year authorizations. 4. Within three years the fossil energy R&D budget should be \$1 billion, which is still less than the non-defense FY-92 nuclear R&D and fusion energy budget requests. Let me be clear that these research programs are important national investments which must be continued. But at this time the priority should be given to a more balanced program that develops our domestic fossil energy resources as rapidly as possible.

Mrs. LLOYD. Thank you very much, Mr. Peoples. It was your recommendation that within three years, the budget should be \$1 billion. I take it you don't agree with Mr. David Freeman that we're rapidly moving away from fossil energy, moving away from coal?

Mr. PEOPLES. I certainly don't agree with that. I believe that with the resources that this country has with fossil energy, we simply need to look at developing what we have. I believe very strongly with other members of the committee or other members of the panel that spoke earlier today that coal and other fossil fuels are going to continue to play a very important part in our energy mix in this country. That is not to say that we can ignore any other form of energy. The nuclear program, obviously, is one that deserves careful consideration, and is, frankly, a program that I think should be continued as well. I think fossil fuels are a part of our energy mix today, a very great part of our energy mix. I foresee that being the same for the next 20 years.

Mrs. LLOYD. You know, I'm of the same mind as you are, Mr. Peoples. I feel that we're almost able to see the light at the end of the tunnel, with only \$70 million. As you know, this committee has been very supportive of the MHD Program all through these many years. Let me ask you, what is going to happen if OMB is successful in cutting out the \$70 million? What are you going to do?

Mr. PEOPLES. I'd hate to even think about that, Madam Chairman. I think, you know, if it comes to an end, I think that the cost-sharing that we've undertaken and the legislation is very clear. MHD is very much a part of the program. I really have serious concerns what that is going to do, frankly, to the entire program. I see that that is really pulling the rug out from underneath of our feet. Could we finish the program with industrial support? I doubt it very much. I think it would be extremely difficult, if not impossible for us to conclude the proof of concept without the fossil energy R&D monies that have been going into the programs. That \$70 over the next two years is going to get us there. If we don't have it, I think indeed it is stopping the race ten yards before the finish line, and \$680 million of taxpayers money is going to be for naught.

Mrs. LLOYD. You mentioned that the Montana Legislature will allow \$50 million for continued development. What is the status of this legislation?

Mr. PEOPLES. The legislation is now before the State Legislature of Montana. It's the Montana Clean Coal Technology Program.

Mrs. LLOYD. Do you think it will pass this year?

Mr. PEOPLES. We're certainly hopeful that it will pass this year. As a matter of fact, the hearing will be on Friday of this week. I'm very hopeful and optimistic that that legislation is going to become reality and that Montana will establish, for the first time, a Clean Coal Technology Program. Specific in that legislation is the fact that MHD is the number one priority.

Mrs. LLOYD. What has been the private sector financial contribution to MHD development?

Mr. PEOPLES. The various companies that have participated, TRW, Avco, Gilbert Commonwealth, have all made contributions in time.

Mrs. LLOYD. I have a list of the companies that are involved. What is the financial contribution?

Mr. PEOPLES. It's about somewhere between 20 percent and 30 percent of the total cost of the program. It's been cost-shared since this committee and the Congress stipulated that cost-sharing was to be a part of the MHD Program. It's a significant part of the program.

Mrs. LLOYD. How does this technology compare with other technologies such as fuel cell technology?

Mr. PEOPLES. Frankly, Madam Chairman, I'm not in any position to give you that comparison, because I'm not a technical person. We truly believe that magnetohydrodynamics is cutting its technology and it's reaching its proof of concept. We're very confident and we think it's a leading technology.

Mrs. LLOYD. We thank you for testimony and thank you for the excellent work that you're doing.

Mr. PEOPLES. Thank you.

Mrs. LLOYD. Wait a minute. I was through asking my questions. Mr. Morrison is going to ask his questions.

Mr. PEOPLES. I didn't think I was going to get off that easy. [Laughter.]

Mrs. LLOYD. No.

Mr. MORRISON. Mr. Peoples, you've mentioned a three year funding path. I think, in your testimony you mentioned two years?

Mr. PEOPLES. In 1993, the proof of concept will end. It is my understanding that the plan, if you may, is a \$40 million appropriation for fiscal year 1992, and then a \$28 million appropriation for fiscal year 1993. That concludes the proof of concept. This year's appropriation was roughly \$40.25 million. We're at that point where we would certainly like additional monies in the remaining years to ensure that if any unexpected occurrence would develop that we would have those covered, and for breakdowns and equipment, etc., that we'd be covered. But we're looking at two years for completion of the proof of concept, fiscal year 1992 and fiscal year 1993. Fiscal year 1992 is roughly at \$40 million; fiscal year 1993 is at \$28 million.

Mr. MORRISON. One of the criticisms of MHD has been that a tremendous amount of money has gone into it in the past and there is some uncertainty as to what is going to come out if we continue the investment. Do you have a reaction to that justification for the volume of money that it has taken to get this going.

Mr. PEOPLES. There is no question that there has been a huge expenditure, national expenditure for the development of this technology, but the payoffs are substantial. If we could retrofit every coal-fired generating facility in this country, we'd solve our environmental problems. It is an expensive technology, yes indeed. But the payoff of that technology, I think, are very substantial and would certainly justify the expenditure that will have been made before the end of the program. The total expenditures that would have been made between the beginning of the program and the end of the program in 1993 would be somewhere around \$750 million. That, obviously, is a large expenditure. When you consider the environmental problems that we're faced with today in terms of acid rain, in terms of global warming, then the payoffs of MHD are certainly substantial and justifiable.

Mr. MORRISON. Thank you. Mr. Fawell, any questions?

Mr. FAWELL. I guess not so much questions as I guess I can have empathy and sympathy for what you have been expressing. I think every energy R&D authorization request is rightly going to bring up the Persian Gulf situation and you're quite right. If that hasn't taught us the lesson that we have to continue with our various options of energy R&D and alternative fuels, I don't know what will.

At the same time, environmental matters continue to be a problem, and that isn't going to change, either. At least before the period of time when you're ready to go out into the world and sell your product, especially at the early stages, we simply have to do everything possible to have the basic R&D. Yet, I think the new energy program of the Federal Government was created after the budget was created. So we're going to hear this kind of testimony and, as I say, I'm not criticizing at all. I am listening, I can tell you, and will be working closely with the Chairman the Ranking Republican Member in regard to how we can have a decent authorization program. It would be good, too, obviously, to have not one year authorizations, but two and three year authorizations so you have some continuities which you can rely upon. This hasn't been a part of our energy programs for quite a while now. So if it helps any, I don't have any real questions, but if it helps any, I can say that I emphasize and sympathize with what you have expressed.

Mr. PEOPLES. Let me just add that as a CEO of a small company that is involved in the MHD Program, I think that the continuity is an extremely important part of that involvement. It's very difficult to operate on a year-to-year basis, not knowing what is going to happen next year or the year down the road. I would certainly agree and echo your comments that the continuity is extremely important in these programs.

Mr. FAWELL. If you're zeroed out this year, what happens?

Mr. PEOPLES. I would even hate to think what would happen. I would think that we had lost a \$680 million or \$660 million federal investment and, frankly, to move forward with a \$40 million private investment in the program, I think, would be extremely difficult, if not impossible.

Mr. FAWELL. Thank you.

Mrs. LLOYD. Thank you very much, Mr. Peoples. We appreciate your testimony.

Mr. PEOPLES. Thank you.

Mrs. LLOYD. Our final witnesses today will be in a panel. They'll discuss the status and the future of fuel cell technology development. Our witnesses are Mr. Frank Schora, President & Chief Executive Officer of M-C Power Corporation, Dr. Jack T. Sanderson, Vice President for Corporate Technology, Asea Brown Boveri, Inc., and Mr. Walt Dollard, Manager of Advanced Energy Conversion Department, representing Westinghouse Electric Corporation. Mr. Schora, please proceed.

STATEMENT OF FRANK SCHORA, PRESIDENT AND CHIEF EXECUTIVE OFFICER, M-C POWER CORP.

Mr. SCHORA. Madam Chairman and members of this subcommittee, my name is Frank Schora. I am President of M-C Power Corporation, a company which we founded solely for the purpose of

scaling-up and commercializing the Molten Carbonate Fuel Cell Technology for electrical power generation. We have teamed with Asea Brown Boveri, a U.S. corporation previously known as Combustion Engineering, and the Institute of Gas Technology to bring the IGT IMHEX molten carbonate technology to commercial reality as quickly as possible. I feel our achievements since our last appearance, or my last appearance, before this subcommittee are significant.

I'd like to submit my written testimony and just summarize briefly.

Mrs. LLOYD. Without objection, all three of you distinguished gentlemen's testimony will be made a part of the record. You may summarize as you wish.

Mr. SCHORA. Thank you, Madam Chairman. To comment on some of the questions that were submitted in the invitation to testify, I also feel that coal will play a very important part in the nation's future for energy supplies and, more specifically, I feel that worldwide, coal will become a major contributor, and continue to be a major contributor for energy.

In that the planet has one biosphere, that really knows no bounds between nations, it's very important that we, as a leader, develop the technology and the hardware to mitigate the damage that can be caused by the improper use of coal where it relates to sulphur and nitrogen oxide emissions. The area that I can claim most expertise in is the fuel cell and, more specifically, the molten carbonate fuel cell, for which we are recommending \$38.5 million for fiscal year 1992. A gas industry R&D task group is now in the process of developing overall fuel cell funding needs for the next several years. This report should be available soon to the committee, I understand. This recognizes that there are two developers of molten carbonate fuel cells in the government-supported program for demonstration of the complete MCFC power system and a third contractor limited to stack development only.

In relation to the question of cost-sharing, under our existing M-C Power contract with the Department of Energy, we are cost-sharing at a level of 30 percent. The request for proposals was originally for 20 percent cost-sharing, however, we deemed it necessary in order to win the solicitation and the competition to raise 30 percent of the monies required.

In response to your question as to which technology is closest to commercialization, we feel the molten carbonate technology ranks well up in that category. We are now projecting commercial readiness of 250 to 500 kilowatt co-generation units by calendar year 1996 to 1997.

To date, our team has experienced total program expenditures since February of 1988 when we put our team together of \$18.16 million, \$13.38 million from the Federal Government and \$4.78 million from industry. Prior to that, IGT in its developmental efforts over the previous 20 years, spent about \$45 million. Roughly, I think half of that was from industry and half of that was from the Federal Government.

We anticipate a need in the next three years of government participation of, at a minimum, \$33.5 million. With this government participation, we must find an additional \$46 million, for a total

program cost of \$80 million during this three year period. We're working intensively with GRI, EPRI and the gas industry and electrical industry to find this money. Of course, federal funding support would be helpful to insure that we meet the \$80,000,000. This is a requirement to maintain our goal of being able to compete with the Japanese, and of having a unit in existence and commercially viable in the 1996/1997 time frame.

I am pleased to report that our commercial facility in Burr Ridge, Illinois, is now in full operation. Our last stack test involved the manufacture totally within our facilities of all the active components of the stack, which was put on test a couple of months ago. It's performance has exceeded that of components that have been manufactured in the laboratory. So, we're very, very pleased with that.

Our next test at M-C Power will be a 70 cell stack, which to my knowledge will be the largest or tallest stack that has been operated to date in the world. This stack, which will be funded by EPRI, will be operated to prove that the type of internal manifolding that we use is successful to commercial application. Once we have completed the 70 cell stack, we plan then to go into a full scale commercial stack, which is 10 square feet in diameter. The plates for that stack have already been received at M-C Power. We will, within the next month, start manufacturing the active components, the electrodes and the electrolytes, for our first test of the full commercial size stack which will occur mid-year of this year. The first one will be a ten cell stack producing ten kilowatts.

The first demonstration stack under the current DOE program will be in Los Angeles at the Union Oil of California's refinery. It will be in cooperation with Southern California Gas Company and the South Coast Air Quality District, who are both contributing to the program.

A second demonstration that we require in a series of seven demonstrations before we can go commercial, the team members have been identified and we are moving ahead to formulate that program at this point in time.

In order to stimulate industries' interest to a greater degree, we have formed the Alliance to Commercialize Carbonate Technology known as ACCT, so that we can better identify what industry, in fact, needs from the standpoint of a fuel cell system, and to gain their participation in these demonstrations which are very costly and should provide some of our cost participation by private industry.

We believe we can meet our objectives, as we are gaining increased support from both GRI, EPRI, and the utility industry. We feel that the molten carbonate fuel cells will have a big impact on the growing energy needs of the country and will replace older, less efficient power generating systems.

I would like to thank this committee for its support in the past few years. In that we probably have the most modern manufacturing facility in the states and probably the world, I'd certainly like to invite the members of this committee to visit.

[The prepared statement of Mr. Schora follows:]

TESTIMONY OF FRANK SCHORA, PRESIDENT & CEO
M-C POWER CORPORATION
SUBCOMMITTEE ON ENERGY
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

March 5, 1991

Madame Chairman and Members of this Subcommittee, my name is Frank Schora. I am President of M-C Power Corporation, a company founded with the sole purpose of scaling up and commercializing the Molten Carbonate Fuel Cell Technology (MCFC) for electrical power generation. We have teamed with Asea Brown Boveri, Inc., a U.S. corporation, previously known as Combustion Engineering, Inc., and the Institute of Gas Technology (IGT) to bring the IGT IMHEx® MCFC technology to commercial reality as quickly as possible. Our achievements since my last appearance before this subcommittee are significant.

Before addressing our specific program on MCFC, I would first like to address some of the questions that we were asked in your invitation to testify. Fossil energy, I believe, will continue to be one of the major sources of energy, if not the major source of energy in the U.S. and throughout the world, for at least the next several decades. Nuclear and renewable energy resources must play an increasing role during this time, but our energy needs will be met, I feel for the most part, by fossil fuels. The use of proper technology in using fossil fuels to minimize environmental concerns due to NO_x, SO_x and CO₂ will be of great importance. Some of this necessary technology has not yet been brought to the point of commercial readiness and technologies that are still in the conceptual stage at this time may play an important future role and should be vigorously pursued. I believe emphasis should be placed on maximizing efficiency in fossil fuel use so as to prolong the availability of this finite resource and to perfect cost effective means to reduce pollutants to an acceptable level.

This planet has one biosphere, which knows no boundaries between nations. It is for this reason that the U.S., as a world leader, must be prepared to develop and supply appropriate technology and hardware to the lesser developed countries who most definitely will use their most available fossil fuels, either correctly or incorrectly with regard to the environment.

There is a need for perfecting cost effective coal gasification and associated gas clean-up. Combined with fuel cells, this technology provides one of the most effective ways to utilize coal for electric power generation. The gasification/fuel cell combination assures maximum system efficiency and minimum production of carbon dioxide for each kilowatt hour of electricity produced. To further maximize the overall utilization of fossil resources the concept of cogeneration must be vigorously pursued.

Although it is not possible for me to project the appropriate level for overall federal funding for fossil R&D activities, I believe it should be a significant part of the total federal energy R&D budget. A decrease in funding as proposed by DOE would paralyze their present R&D efforts.

The area that I can claim some expertise in is fuel cells and more specifically, the Molten Carbonate Fuel Cell, for which we are recommending \$38.5

million for FY92. A gas industry R&D task group is now in the process of developing overall fuel cell funding needs for the next several years. The number should be available soon. These numbers will recognize there are now two developers of MCFC's in the government-supported program for demonstration of the complete MCFC power system and a third contractor limited to stack development only.

The concept of requiring cost sharing from the private sector for all R&D programs as a validation of industry interest in a technology can have a chilling effect on the ability of the federal government to pursue energy R&D. The requirement for cost-sharing should take into account the stage of development a technology and the financial ability of a developer to participate in cost sharing. Where R&D is in an early stage of development, the government should carry most, if not all of the cost burden. Heavier cost sharing by the private sector is appropriate only when the technology approaches commercial readiness.

Many start-up firms that have limited assets do not have the same ability to cost share as do larger, well established companies. In the U.S. a preponderance of new technology is developed by the newer and smaller companies. By demanding large cost sharing, the availability of these firms to apply their entrepreneurial ability to the fossil R&D program will be diminished. This is something the U.S. can ill afford in our push to solve our energy and environmental problems and to maintain our technical creativeness in this increasingly competitive world. Requiring cost participation at the 50% level is excessive except in the final phase prior to commercial application.

Under our existing M-C Power contract with DOE, our team is cost sharing 30% of the program costs. The request for proposals for that contract specified at least 20% cost sharing in order to compete. Our team achieved a 30% participation level which we deemed necessary in order to win. We were able to do this only because of the promise our technology holds to industry and the technology's state of development. M-C Power would not have been able to provide the cost-sharing alone. If a firm has excellent technology but lacks the ability to cost share or to obtain such cost sharing from industry, valuable technology can be lost.

In response to your question as to which technology is closest to commercialization, I believe that the molten carbonate fuel cell technology fits this category. We are projecting commercial readiness of 250-500 kW cogeneration units by the calendar years 1996-97.

In order to continue meeting our objectives, this testimony recommends an FY92 authorization \$38.5 million in the Department of Energy's Molten Carbonate Fuel Cell development program. My recommendation recognizes that there are now two developers of MCFC's in the government-supported program for demonstration of the complete MCFC power system and a third contractor limited to stack development only. The specific level of funding we are requesting in FY 92 for the M-C Power's team effort is \$18.5 million: \$10 million to cover our U.S. DOE program requirements during FY92, \$3 million to cover the shortfall of U.S. DOE funding during FY91 and \$5.5 million to start stack design and fabrication for our second power plant demonstration at a commercial site.

To date our team has experienced total program expenditures since February, 1988 of \$18.16 million, \$13.38 million from the federal government and \$4.78 million from industry. In the next three years, based on our current contracts with DOE, DOE's recent request for proposal for stack demonstration, and other

anticipated RFPs to assist us in stack development, we hope for total federal government participation of \$33.5 million. Even with this government participation we must find an additional \$46.5 million for a total cost of \$80 million to keep our program on schedule. We are working intensively with GRI, EPRI and industry to find this money. Additional federal support would help ensure meeting our \$80 million goal on schedule.

Under our current DOE contract we expect to complete operation of a dual-fueled coal gas/natural gas 250 kW demonstration plant by the end of 1993. An integrated proof of concept demonstration using a system specific to natural gas as a fuel is targeted for mid-to-late 1994. This will be followed by two additional units which will be tested during late 1994 and mid 1995. Four additional units will be built and tested before market entry in 1996-97. We will be doing everything possible to shorten this time frame in order to reach the market as soon as possible. If federal and private sector funding is not available, then this schedule will clearly lengthen. Our target is to get to the marketplace at or before the time off shore developers do.

The MCFC continues to look very promising as an electric power generating concept, with a potential efficiency of up to 55% when using coal as fuel and as high as 62% for natural gas based systems. Operation at 1200°F enables very effective use of waste heat in cogeneration applications, supplying either space heating, air conditioning or industrial process heat. In large utility systems, this heat can be used in bottoming cycles, so as to achieve the maximum possible use of the heating value of the fuel, important for conservation of our natural resources. Because of its low operating temperature, NO_x emissions are very low compared to conventional combustion-based power generation and, because the MCFC will not tolerate sulfur in the fuel gas, sulfur compounds are removed from the fuel, thus eliminating sulfur oxide emissions. In view of these characteristics, the MCFC can be considered essentially a non-polluting device. Its high efficiency also ensures the lowest carbon dioxide emission per kilowatt of electricity produced, thus minimizing contributions to any possible greenhouse effect.

M-C Power has invested significantly in our facilities and manufacturing operations, which is one of the most modern molten carbonate fuel cell component fabrication plants in the world. The present annual manufacturing capacity is 3 MW, which we now believe can be increased to 12 MW with the addition of a second tape casting line and going to multiple shift operations.

In our team, ABB is responsible for the design and fabrication of the balance of plant, while M-C Power concentrates on the IMHEx stack design and manufacture. IGT, the world pioneer in MCFC development, provides the needed technical support for improvement of electrodes, electrolytes and stack concepts. ABB will take the lead role in developing the market and will provide sales and service both in the U.S. and elsewhere. Based on the expertise brought by the various team members, we feel this teaming arrangement is an excellent approach to the commercialization of this very promising technology.

I am pleased to report that all segments of our commercial manufacturing facilities are operational. We have just completed a test on the first one square foot stack assembled at M-C Power using active components manufactured on our commercial equipment. I am pleased to report that this stack has outperformed previous IMHEx stacks tested which were assembled from components manufactured in the laboratory. This test was funded by the Gas Research Institute. We are now in the process of building our next test stack which will

have 70 cells, which, to my knowledge, will be the largest number of cells to be tested in a single stack by anyone to date. This one square foot stack, being built under funding from EPRI, will be operated to prove conclusively that the IMHEX[®] design, which is internally manifolded, has eliminated so called carbonate pumping which results in shortened stack life. This phenomenon, observed in externally manifolded stacks, has been one of the major problems confronting stack developers.

Tests of the IMHEX[®] concept have been conducted to date using stacks of 1 square foot cross sectional area. The design and fabrication of our first commercial stack of 10 square foot cross sectional area is well underway. The full size separator or bi-polar plates have been designed, the dies fabricated, and the first sixty plates pressed and received for final fabrication. Manufacture of the 10 square feet electrodes and electrolyte tiles will be initiated at M-C Power in the next month. Initial manufacturing tests undertaken producing components of this size have shown favorable results. We plan to assemble and test our first full area stack by the middle of this year. This first full-area stack will have 10 kW output and will consist of ten cells.

The first demonstration stack under our current DOE Contract DE AC21-90MC-27394, will be a 250 kW cogeneration facility to be located at a Union Oil of California (UNOCAL) facility in Los Angeles. Cooperating in this demonstration with UNOCAL, as part of our team, will be Southern California Gas Company and the South Coast Air Quality Management District. The IMHEX fuel cell stack will be designed with the capability of operating on either reformed natural gas or coal based gas.

In order to achieve commercialization as quickly as possible, the M-C Power team has already identified a second demonstration partner and is working with them to finalize arrangements. We plan to submit a proposal to DOE for funding of the stack for this second 250 kW demonstration under the February 12, 1991 U.S. DOE Solicitation for Cooperative Agreement Proposal for "Molten Carbonate Fuel Cell Stack Demonstration." We are also in discussions with several other utilities for additional demonstration sites needed to facilitate our field tests prior to offering the IMHEX[®] system for commercial sale.

We are looking toward the middle of this decade for commercial introduction. Our target is to offer commercial MCFC systems by the mid-90's, initially at the 250 kW power level for cogeneration application using natural gas and then for larger utility-type applications in the multi-megawatt range using natural gas or coal derived gas.

As part of our commercialization effort, we are currently contacting many utilities to determine their interest, needs and possible support. In order to facilitate this activity we are creating an organization known as the "Alliance to Commercialize Carbonate Technology" (ACCT), to be comprised of utilities and other end users working toward a better definition of MCFC system requirements. To date, we have 16 utilities interested in attending the initial meeting, where we will finalize the framework and functions of this organization.

Our team's goal is to work closely with the utilities through ACCT so that the IMHEX[®] systems will be of appropriate output, both electrical and thermal, to meet the demands to be placed on them. In addition to the smaller 250 kW cogeneration systems we also look to supplying multi-megawatt systems for distributed and central power station applications and seek industry guidance on these systems as well.

We believe we can meet our objectives, as we are obtaining increased financial support from both GRI and EPRI, which we need along with the continued support from DOE. The impact and use of molten carbonate fuel cells to supply the growing energy needs and to replace the older, less efficient, pollution creating, power generating systems, both in the U.S. and throughout the world, will be significant. It will reduce the demand on fossil fuel reserves, while aiding greatly in improving our environment.

I thank you for the opportunity to appear before this subcommittee and would be pleased to answer any questions.

Mrs. LLOYD. Thank you very much. We are going to have to break here for a vote. We'll be back shortly. Thank you very much. We regret this inconvenience.

[Recess.]

Mrs. LLOYD. We apologize for the delay. We will resume our hearings. Mr. Sanderson, please proceed.

**STATEMENT OF JACK T. SANDERSON, VICE PRESIDENT FOR
CORPORATE TECHNOLOGY, ASEA BROWN BOVERI, INC.**

Mr. SANDERSON. Thank you, Madam Chairman. I would like to thank the committee for the opportunity to appear here today. Perhaps, as I have my formal statement for the record, I would just like to say a few words in the interest of time. Our industry is a very normal industry in most respects. That is, to introduce technology or to introduce new products into the market place, we're driven by a number of factors. Environmental issues are a major concern. Capital costs and the cost of a new plant are a major concern. Efficiency and reliability are major concerns. Certainly, in the energy area lately, a major concern has been flexibility, the ability of a plan to adjust as the cost of different fuels changes, one relative to another.

I think for all of these reasons, the fuel cell program, and particularly the fuel cell molten carbonate activities, are a very important new technology coming onto the scene. In all of these areas, the molten carbonate fuel cell has the ability to perform at or better than any of the competitive systems, in my belief.

Certainly, in the environmental area, the molten carbonate fuel cell itself process no knocks, or virtually no knocks. The sulfur is normally removed before the gas goes into the fuel cell so there are no SOX emissions. Particulate emissions are very low and other environmental pollutions are very low. I believe I have in my statement some data on that.

In terms of capital costs, we are still in the early days of commercializing molten carbonate fuel cells. The commercialization itself is high risk, high cost, but we believe that the capital costs of a fuel cell operated plant will be highly competitive with other conventional sources of energy.

In terms of efficiency and reliability, we are still in the course of proving that, but we currently are looking at efficiency factors of 60 percent for electrical generation with natural gas, and up to about 55 percent efficiency using coal gas, gas made from a gasifier. This compares very favorably with even the most modern of fossil coal burning plants, which are more nearly in the 40 percent range, or the average fossil plant, which is closer to 30 percent. In that respect I would like to point out that the efficiency of these is directly related to the greenhouse gas emissions.

Mr. Schora has told you much about the activities of the ABB/M-C Power IGT team. I would simply point out that ABB's role on the team is to provide the overall systems design to build the balance of the plant; that is, all the pieces, equipment and controls that are necessary to take a stack of fuel cells and convert them into an operating unit that delivers the electricity to the customer, the heat to the customer.

We are also currently responsible for the commercialization strategy; marketing, selling, and servicing of the IMHEX molten carbonate systems.

Our current view is that we will be introducing MCFC fuel cell systems into the co-generation market in about the year 1995, with shipment and installation probably in 1996. We anticipate it will go from there to multi-megawatt units operating as distributed power sources for industrial complexes and in substations throughout the country. Finally, we will go to large central stations as part of a coal gasification fuel cell system.

This combination appears to offer a great deal in our coal based and in our natural based economy. It offers a smooth transition for coal with a very high efficiency. It offers a high efficiency distributed system for co-generation, so that one can put the power plant in the shopping center, in the hospital, in the local neighborhood, causing no disturbance to the neighborhood, and providing a source of heat and thermal energy as well as the electricity.

Overall, we have found that in the last twenty years, we have made significant progress. A great deal of progress in the last three years was supported by the Department of Energy, by industry, by ourselves and by EPRI and GRI and the other utilities. I think it's important, at this point, to emphasize, however, that although I'm very optimistic, although I'm convinced that we will have a product in the market by about 1995, 1996, the cost and the risk at this point is still very high. We have an arrangement which is a contract with the Department of Energy for the first 250 kilowatt unit. I must say that I am very troubled by suggestions that DOE might want to change the cost-sharing arrangement that is in that existing contract. I believe it would cause us a great deal of difficulty. I think certainly as we move to introduce this new technology, as we go ahead to combine it with gasification, there has to be a large and continuing role for the Department of Energy.

I think with that, I would simply like to emphasize that industry is supporting this program very heavily. We are putting a substantial amount of cost sharing in. At present, with DOE, we are cost-sharing about 30 percent on our project. In fact, we are putting additional funds in to accelerate this program, as well.

I would like to respond to any questions, Madam Chairman. I believe we have a great opportunity here.

[The prepared statement of Mr. Sanderson follows:]

Statement of
JACK T. SANDERSON
Vice- President, Corporate Technology
Asea Brown Boveri Inc.

Chairperson Lloyd and Members of the Committee. Thank you for the opportunity to appear before you today to support the Department of Energy fuel cell program. I believe that this is an important program for the United States, both because of the economic contribution this technology can make to the US and because of the environmental and energy saving potential for the country.

I am Jack Sanderson, Vice President for Corporate Technology for Asea Brown Boveri Inc., a U.S Corporation chartered in the State of Delaware. With a few time-outs for other jobs, I have been involved in fuel cell activities for well over a decade, dating back to my time as an Assistant Director at NSF. I am currently responsible for the ABB Inc. fuel cell programs, which encompass both Molten Carbonate (MCFC) and Solid Oxide (SOFC) fuel cells.

Like all fuel cells, MCFC and SOFC can convert chemical energy directly into electrical energy without an intermediate thermal or mechanical cycle; which offers the potential for higher electrical efficiency. Unlike other fuel cells these also operate at high temperatures (greater than 1200°F for MCFC's), so that the heat

efficiency of MCFC's in an advanced system for electrical generation is expected to be in excess of 60%; when you also take advantage of thermal energy the overall efficiency can easily exceed 80-85%, compared to a modern coal burning power plant at about 40% efficiency. This increased efficiency converts directly into reduction of greenhouse gas emissions.

I would like to focus today on the status of molten carbonate fuel cells, the DOE program to support R&D for MCFC's, and what ABB, with its other partners, is doing as a part of that program.

I believe that MCFC's offer the best promise for improving electrical energy efficiency, reducing environmental pollution, and entering the market this decade. (See Attachments) Other types of fuel cells have established positions in specialty applications - space or other unique markets, but these generally operate at lower temperatures, provide less overall efficiency and have higher capital cost than MCFC's, or are further from commercialization at a competitive cost. Further, MCFC's can operate using a variety of fuels; natural gas, coal gas from gasifiers, or process gases from industrial plants.

We at ABB Inc. are dedicated to the development and commercialization of MCFC's as part of a team with M-C Power and the Institute of Gas Technology (IGT). In this team IGT, a not-for-profit research organization, has a history of more than 25 years research on MCFC's. They provide a strong, and continuing

research base on cell technology. M-C Power is a joint venture corporation set up by ABB, IGT and others expressly to further MCFC technology and to develop manufacturing capability for MCFC cells and cell stacks in the United States. In addition to being a partner in M-C Power, ABB's role on the team is to provide systems design, control engineering, component fabrication, site erection, and environmental impact assessment. ABB is also responsible for commercialization strategy, marketing, selling and servicing of the MCFC systems. We are currently examining the application of these fuel cells in distributed cogeneration systems (250KWe and larger), gas fired dispersed site and central electrical generation (ranging from several megawatts to >100 MWe) and in combination with coal gasification for coal fired central power plants. We believe that MCFC's can significantly increase efficiency, reduce greenhouse and acid gas pollution, and be cost competitive with other technologies in all three areas.

Our team is working exclusively on the IMHEXTM system for MCFC's. This unique design provides a simpler, more reliable design for the fuel cell system and at the same time appears to have solved one of the most significant problems limiting the life of MCFC fuel cell stacks -- carbonate pumping from one cell to another; where the life of a stack is limited by a change in distribution of chemicals within the cells as they operate. We now achieve power densities greater than 110 W/ft², compared with less than 10 W/ft² when IGT started the program.

About four months ago, in cooperation with two utilities, we formed the Alliance to Commercialize Carbonate Technology to promote the development and commercialization of MCFC's. Since then sixteen power generators and consumers have joined, and I had two more expressions of interest from European utilities last week. This membership will continue to grow as awareness of ACCT spreads and data emerges from our program.

I hope that I sound very positive about the program, I am. But it has and continues to depend heavily on the DOE fuel cell program for support. Even though results to date are very positive the cost and risk remains high and industry cannot fund the program alone. The remarkable progress that our team has made in the past few years was supported in part by DOE, GRI, EPRI and other funding. While we are cost sharing significantly in the program, it is important that the government role not be diminished during the next several years as we proceed through this high cost, high risk period. With this support we are today moving at the pace needed to establish US leadership in this technology and to realize the environmental benefits MCFC's can offer.

Today I want to recommend funding of \$18.5 Million in FY'92 in the DOE program specifically for development of IMHExTM MCFC systems. Specifically, ABB Inc is requesting \$10 Million in FY'92 to address the objectives in the ABB Team's program with the US DOE; an additional \$3 Million to restore a shortfall that occurred in funding the 1991 program that may cause a stretch in schedule;

and a further \$5.5 Million to initiate stack engineering and fabrication for our first cogeneration power plant designed to demonstrate feasibility under commercial operating requirements.

Currently, with the projected program for FY'93 and '94 we are requesting an additional \$14.9 Million from DOE for IMHEXTM technology, for a three year total of \$33.4 Million. This will be supplemented with additional funding from the IMHEXTM team, GRI, EPRI and the utilities. With this level of support I believe that you can see commercial cogeneration using MCFC's by the middle of the decade and full scale central power generation facilities by early in the 21st Century.

The first commercial uses will be in units of 250-500 KWe, the size needed for hospitals, shopping centers and large building complexes. ACCT members have identified this need for California, Florida, the East Coast and other areas where cogeneration is attractive but the environmental constraints make siting other types of facilities difficult.

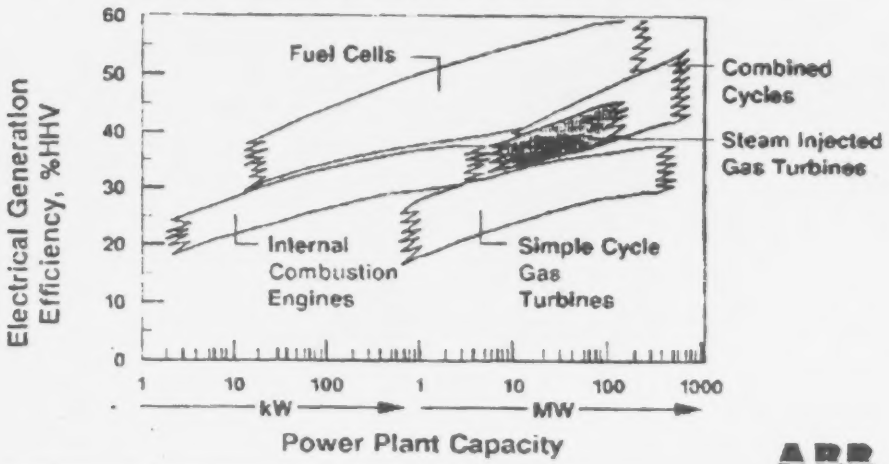
We then plan to increase system output by using experience gained on these units to produce multi-megawatt units for industrial cogeneration and dispersed site power generation. The latter market is of particular interest to ABB. We envisage central computer control of numerous 10-50 MWe natural gas fueled IMHEXTM systems located at sub-stations throughout metropolitan areas, providing electricity directly to the distribution networks.

Cost for high voltage transmission lines, right-of-way problems and public concern about low frequency electromagnetic radiation are reduced.

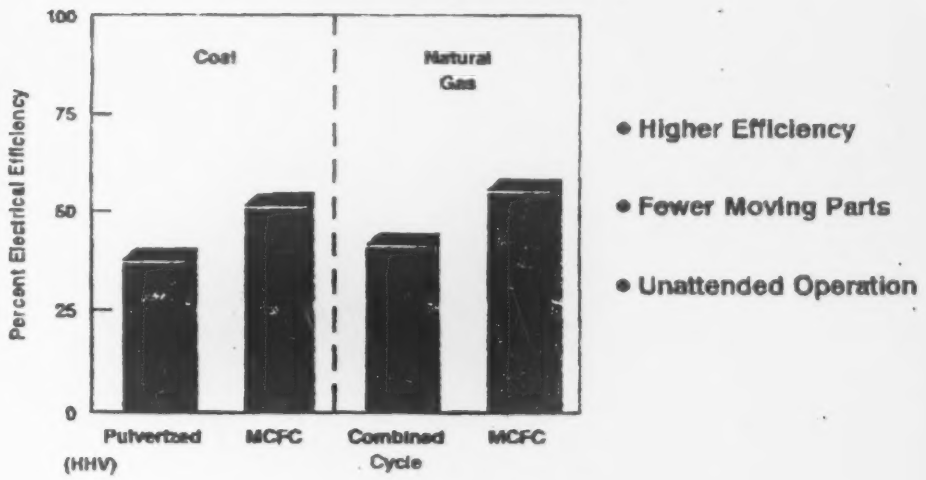
Finally, we believe that coal derived gas will become cost competitive and that there will be a significant need to repower older coal fired generating facilities to reduce environmental impact and increase power production. In this application our IMHEX[™] technology can increase efficiency, reduce greenhouse gas emissions and provide lower cost electricity for the consumer.

Thank you for this opportunity to testify today on behalf of MCFC's and the IMHEX[™] team. I would be pleased to answer any questions.

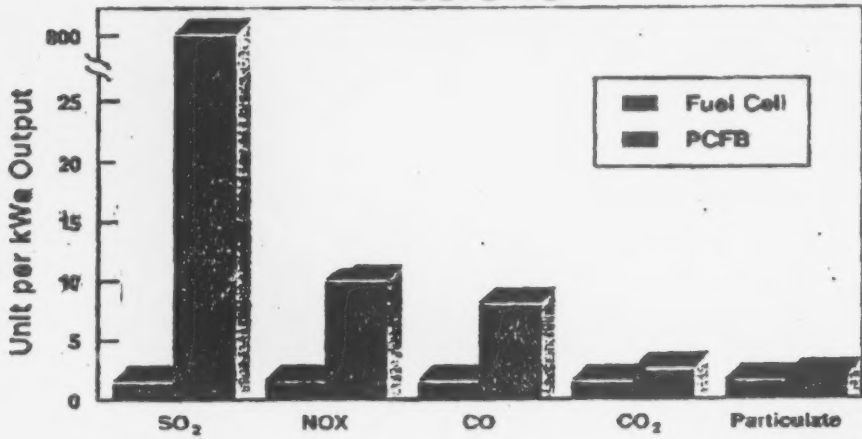
PERFORMANCE COMPARISON NATURAL GAS POWER GENERATION

**ABB**

COST EFFECTIVE



COMPETING COAL TECHNOLOGIES EMISSIONS

**ABB**

Mrs. LLOYD. Thank you, very much. Mr. Dollard, please proceed.

STATEMENT OF WALTER J. DOLLARD, MANAGER OF ADVANCED ENERGY CONVERSION DEPARTMENT, WESTINGHOUSE ELECTRIC CORP.

Mr. DOLLARD. Thank you, Madam Chairperson. I am Walter Dollard. I am the manager of the Advanced Energy Conversion Department of the Westinghouse Science and Technology Center. The Science and Technology Center is the central corporate organization made of 1,200 people with the mission of leading the corporation in advanced technology and passing that on to our business units. Can you hear me all right?

Mrs. LLOYD. Yes, we can, thank you.

Mr. DOLLARD. Madam Chairperson, I think listening to the various testimony here, I don't want to bore you with the repetitiveness of much of what I have presented in the written material which is before you. I think, therefore, what I should try to do is make some points that possibly some of the others have not chosen to make in their verbal presentations, though they have been in their written presentations.

Mrs. LLOYD. Please proceed.

Mr. DOLLARD. I think it's important to make the point that demand for electricity continues to rise throughout the world. Few people realize that even today, fully 75 percent of the world's population is not connected to an electrical supply system. What that means is there is going to be a considerable increase in energy needs throughout the world, putting an even tighter grasp on the supply of fossil fuels.

The global environmental issues that accompany the burning of fossil fuels have aroused great concern. Of course, the Greenhouse is just one example of that, but the issue basically is that coal, oil, natural gas, and their by-products are a chief contributor to worldwide air pollution. They emit sulfur, nitrogen oxides, carbon dioxide, and other substances that create severe consequences for plant and animal life on our planet.

Fuel cells are one of the most promising areas, in our belief, to help alleviate those problems. Fuel cells can be made in modular packages under factory conditions. This will reduce the lead time for power plant construction, minimize erection costs and permit higher levels of quality control. Modularity also permits utilities and other users to match the size of the plant to the actual load that they are seeing.

There is virtually no limitation to where a fuel cell power plant can be cited. The plants are very compact and virtually noiseless. They can be used with a variety of fuels, and the waste heat from fuel cell operation can be readily utilized. Therefore, a fuel cell power plant can be used either for baseload or intermediate all-electric power plant, as well as for a co-generation plant.

There are three basic types of fuel cells, phosphoric acid, molten carbonate, and solid oxide. I'm not going to go into the differences, but I'd like to give a little observation with regard to these three types.

The phosphoric acid fuel cells are the closest to becoming a commercial reality. On the other hand, molten carbonate and solid oxide fuel cells offer the highest obtainable efficiencies and better potential, possibly, for coal-based power generation.

Significant investment is being made in the development of each of these fuel cell technologies. Principal efforts are in Europe, Japan, and the United States. Let me take a few moments to present a brief survey of some of these fuel cell developments.

The European community's interest in fuel cells has been sparked by several factors. Most important, there, is the potential of fuel cells to reduce environmental pollution and provide the modularity to allow dispersed citing and fast construction to keep up with the growing electrical demand. They are concentrating attention on plants in the range of tens of kilowatts to millions of kilowatts for commercial, industrial, and utility applications, as well as some effort for land and sea transportation.

The EEC is working in three major areas. On molten carbonate fuel cells, especially in The Netherlands and Italy, these projects are focused on technological problems. The Europeans are also working on the further development of solid oxide fuel cells. The EEC began its Solid Oxide Fuel Cell Program in 1987. Laboratories in France, Norway, Germany, The Netherlands, and England are presently involved.

This program's major objectives are the fabrication and evaluation of small cells with newly developed systems concepts and the evaluation of new cathode and electrolyte materials.

Finally, the Europeans are actively applying near commercial phosphoric acid fuel cells developed in the United States and Japan, as well as making investments in U.S. fuel manufacturing operations.

In Japan, as one might expect, a broad effort is underway by industry and government to develop new, high-efficiency power plants that will result in lower energy costs and promote a cleaner environment.

The comprehensive joint industry and government Fuel Cell Power Generation Development Project is under the auspices of the Ministry of Trade and Industry's "Moonlight Program", with which many of you are familiar. Present activities include basic research on all the types of fuel cells, as well as the development of demonstration power plants that produce electricity in the several megawatt range.

Funding for this program by the Japanese government was originally established at \$44 million, \$30 million of which was earmarked on phosphoric acid fuel cells.

However, this funding was subsequently increased, probably to the level of over \$100 million per year, to complete development of the phosphoric acid fuel cell, and to provide for the commercialization of a second-generation molten carbonate fuel cell technology, and, now, the solid oxide fuel cell.

The Moonlight fuel cell effort achieved a major milestone in 1987 and 1988 when two 1,000 kilowatt phosphoric acid fuel plants were tested.

Tokyo Electric Power Company has operated a 4,500 kilowatt unit and is presently constructing an 11,500 kilowatt plant using

phosphoric acid fuel cells provided by the International Fuel Cells, a joint venture between United Technologies and Toshiba. These are the largest fuel cell power plants in the world.

Turning now to molten carbonate fuel cell development, Hitachi, Toshiba, Mitsubishi, Fuji Electric, and Ishikawajima-Harima have developed several one kilowatt fuel cell stacks as early as 1984 and 1985. Currently, stacks up to 30 kilowatts have been tested.

Present plans include developing a 100 kilowatt stack this year and constructing a 1,000 kilowatt molten carbonate fuel cell plant by 1995.

In work on solid oxides, the Japanese Government's Electrochemical Laboratory has operated a one kilowatt generator. Mitsubishi Heavy Industries, in conjunction with Tokyo Electric Power Company, has a large program to develop solid oxide fuel cell generators.

Although there has been keen interest in fuel cell technology in the United States for aerospace and military applications, this interest has more recently been expanded to the commercial market. This is largely the result of the energy crisis of the mid-1970s, and the strong effort by government and industry.

I'm not going to repeat the various interests of people in molten carbonate. That has very well been discussed by my colleagues here. But, there are currently over fifty 200 kilowatt phosphoric acid fuel cell plants being built by Internal Fuel Cells for operation in the United States and Japan.

Westinghouse is in the final phase of an air cooled phosphoric acid fuel cell technology. In a cooperative government/industrial funded program, this technology has advanced to the point of demonstrating its commercial readiness. Using private sector funds exclusively, a three year project has been undertaken to integrate a 400 kilowatt air cooled phosphoric acid fuel cell module into a European industrial plastics plant. In this application, excess hydrogen produced as a by-product in the plastic manufacturing process will be used in the fuel cell to produce the DC power required for the plant's electrolysis operations. Industrial applications of this type are abundant in the United States and represent a commercial opportunity for the technology, thereby reducing the power demands of this energy intensive industry.

We've talked about molten carbonate fuel cells. I'll talk a little bit more about solid oxide fuel cells.

The work performed at Westinghouse is indicative of the substantial effort and financial resources that fuel cell technology is receiving in the United States.

The tubular solid oxide fuel cell generator was developed by Westinghouse and today the corporation is committed to the development and commercialization of solid oxide fuel cells. For more than two decades, Westinghouse has been developing the materials and establishing the processes for this technology.

Westinghouse has already achieved several important milestones towards commercialization. The three kilowatt systems have been built by Westinghouse and operated by gas companies in Japan. Availability was extremely high, at 98 percent. Emissions were low; nitrogen oxide emissions were no more than two parts per million.

Noise levels were less than 60 decibels, less than what I'm speaking to you today.

If similar levels of nitrogen oxide emissions are achieved in larger units, they will be several orders of magnitude under the level gas engines are projected to receive at the year 2000. In addition, these high temperature fuel cells produce far less carbon dioxide, the primary factor contributing to global warming, because of their higher efficiency.

The units operated by Tokyo Gas and Osaka Gas, and a demonstration conducted by the Tennessee Valley Authority, exhibited the ease of installation, unattended operation, and simplified maintenance in the field.

A 20 kilowatt system has recently been put on test under a U.S. DOE/Westinghouse Program, using natural gas directly from the pipeline. 25 kilowatt systems are under construction for operation by Japanese utilities.

The total expenditure for the two Westinghouse fuel cell development programs, i.e., the phosphoric acid and solid oxide systems, is approaching \$200 million, and is not yet half finished.

I hope to have shown that development of fuel cell technologies is being carried out by competent organizations throughout the world. Indeed we are in a race to lead these technologies with foreign organizations, well funded by governmental, quasi-governmental, or institutional interests. These programs are very expensive, technologically risky, and require a long term staying power.

I guess I don't have to say to you, Madam Chairman, because I heard you say the same words before, that it is in that light that increased, long-term and consistent government support is needed in order to maintain our current slight technological edge. Thank you very much.

[The prepared statement of Mr. Dollard follows:]

TESTIMONY BEFORE THE
SUBCOMMITTEE ON ENERGY
of the
HOUSE SCIENCE, SPACE, and TECHNOLOGY COMMITTEE

by
WALTER J. DOLLARD
WESTINGHOUSE ELECTRIC CORPORATION
MARCH 5, 1991

Thank you. I am Walter Dollard and I am the manager of the Advanced Energy Conversion Department of the Westinghouse Science and Technology Center. The Science and Technology Center is the central corporate organization made up of 1200 people with the mission of leading the corporation in the advanced technology development and transfer to business units.

Our fossil energy program is most important because it provides for the development of our most abundant energy resources, our most utilized energy source, and our most imported energy resources. It is vital to our country that these fossil fuels be developed and used in the most cost efficient way consistent with the needs to protect our environment. The subject that you must deal with is very broad. I think my contribution can best be served by concentrating my testimony on that portion of fossil fuel technology that I know best, the fuel cell.

Although fuel cell technology has been under development for several decades, it has only been in recent years that fuel cells have attracted considerable global attention. Nations everywhere recognize the need for more efficient forms of energy conversion, especially to electricity to meet growing long-term, world-wide requirements. In addition, there is widespread concern over environmental issues that impact all peoples.

The demand for electricity will continue to rise, especially in eastern Europe and the Pacific Region. Few people realize that even in this so-called modern era, fully seventy-five percent of the world's population is not connected to an electrical supply system.

While the demand for electricity continues to escalate, global environmental issues that accompany the burning of fossil fuels have aroused great concern. The recent publicity on the Greenhouse effect is just one example. The point is: coal, oil, natural gas, and their by-products, are a chief contributor to worldwide air pollution. These emit sulfur, nitrogen oxides, carbon dioxide and other substances that create severe consequences for plant and animal life on our planet.

Many new technologies are being investigated in our search for ways to find clean, efficient processes to meet the increasing worldwide need for electricity.

Among the most promising of these new technologies is the fuel cell.

Fuel cells are a power generation technology that can cleanly and efficiently utilize our fossil fuel supplies. Market potential for the technology extends from small commercial and small industrial applications to larger plants for industrial cogeneration ... to all electric utility applications.

A fuel cell is similar to a battery: it consists of a positive anode, a negative cathode and an electrolyte that carries current ... it conducts electricity. The primary difference is that a storage battery consumes its electrodes and then ceases to operate -- in everyday language: it goes "dead." In a fuel cell, on the other hand, the electrode is not consumed but acts as a catalyst to burn fuel.

The present-day renewed interest in fuel cells stems from several inherent benefits of the fuel cell over conventional means of producing electricity:

- The electrical efficiency of the fuel cell can be greater than 50 percent, in contrast to a typical, coal fired power plant that is typically 30 or 40 percent.
- Fuel cells can be made in modular packages under factory conditions. This will reduce the lead time for power plant construction, minimizes erection costs and permits higher levels of quality control. In addition, modularity permits utilities or other users to match the size of the plant to actual load growth.
- There is virtually no limitation to where a fuel cell power plant can be sited. Plants are relatively compact and virtually noiseless.
- Fuel cells can be used with a variety of fuels, and the waste heat from fuel cell plant operation can be readily utilized. Therefore, a fuel cell power plant can be used either for baseload or intermediate load all-electric power plant operation or as a cogeneration plant.
- Fuel cells have almost no harmful emissions.

The principal of the fuel cell has been understood for about a hundred and fifty years, and the first kilowatt-scale fuel cells were demonstrated several decades ago.

There are three basic types of fuel cells -- based on the material used as the electrolyte -- receiving widespread attention today ... the phosphoric acid fuel cell, the molten carbonate fuel cell and the solid oxide fuel cell.

The primary difference among these three are that the electrolyte for phosphoric acid and molten carbonate fuel cells is in the liquid phase during operation and must be replenished during the operational life of the cell; whereas the Solid Oxide Fuel Cell is a solid-state device, so the electrolyte does not need to be replaced. This simplifies design, operation and maintenance as well as having the potential to reduce costs.

Phosphoric acid fuel cells are the closest to becoming a commercial reality.

On the other hand, molten carbonate and solid oxide fuel cells offer the highest obtainable efficiencies and the potential for coal-based power generation.

Significant investment is being made in the development of each of these fuel cell technologies. Principal efforts are in Europe, Japan and the United States. Let me take a few moments to present a brief survey of some of these fuel cell developments.

The European community's interest in fuel cells has been sparked by several factors. Most important is the potential of fuel cells to reduce environmental pollution and provide the modularity to allow dispersed siting and fast construction to keep up with the growing electrical demand. They are concentrating attention on plant capacities in the range of tens of kilowatts to millions of kilowatts for commercial, industrial, and utility applications as well as for land and sea transportation.

The EEC is funding work in three major areas:

- on molten carbonate fuel cells in The Netherlands and Italy. These projects have focused on solving basic problems such as nickel dissolution and internal fuel reforming ... or the way hydrogen is produced within the cell from natural gas.
- The Europeans are also working on the further development of solid oxide fuel cells. The EEC began its Solid Oxide Fuel Cell Program in 1987. Laboratories in France, Norway, Germany, The Netherlands and England are presently involved.

This program's major objectives are the fabrication and evaluation of small cells with newly developed systems concepts, and the evaluation of new cathode and electrolyte materials.

- And, finally, the Europeans are actively applying near commercial phosphoric acid fuel cells developed in the United States and Japan, as well as making investment in U.S. fuel cell manufacturing operations.

In Japan, as one might expect, a broad effort is underway by industry and government to develop new, high-efficiency power plants that will result in lower energy costs and promote a cleaner environment.

The comprehensive joint industry and government Fuel Cell Power generation Development Project is under the auspices of the Ministry of Trade and Industry's "Moonlight Program," with which many of you are familiar. Present activities include basic research on all the basic types of fuel cells as well as the development of demonstration power plants that produce electricity in the several megawatt range.

Funding for this program by the Japanese government was originally established at \$44 million ... \$30 million of which was earmarked for work on phosphoric acid fuel cells.

However, this funding was subsequently increased, probably to the level of over \$100,000,000 per year to complete development of the phosphoric acid fuel cell and to provide for the commercialization of a second-generation molten carbonate fuel cell technology, and, now, the solid oxide fuel cell.

The Moonlight fuel cell effort achieved a major milestone in 1987 and 1988 when two one thousand kilowatt phosphoric acid fuel cell plants were tested. These convert natural gas to grid-quality AC electricity.

Tokyo Electric Power Company operated a 4500 kilowatt unit and is presently constructing an 11,500 kilowatt plant using phosphoric acid fuel cells provided by International Fuel Cells (IFC), a joint venture between United Technologies and Toshiba. These are the largest fuel cell power plants in the world.

Turning now to molten carbonate fuel cell developments, Hitachi, Toshiba, Mitsubishi, Fuji Electric and Ishikawajima-Harima developed several one kilowatt fuel cell stacks in 1984 and 1985. Currently, stacks up to 30 kilowatts have been tested.

Present plans include developing a 100-kilowatt stack this year and constructing a 1000-kilowatt molten carbonate fuel cell plant by 1995.

In work on solid oxides... The Japanese Government's Electrochemical Laboratory has operated a 1 kilowatt generator. Mitsubishi Heavy Industries, in conjunction with Tokyo Electric, has a large program to develop solid oxide fuel cell generators.

Although there has always been keen interest in fuel cell technology in the United States for aerospace and military applications, this interest has more recently been expanded to the commercial market. This is largely the result of the energy crisis of the mid-1970s and the strong effort by government and industry to decrease the nation's dependency on foreign oil.

Several U.S. manufacturers have developed a deep understanding of fuel cell technology. Among these are the Energy Research Corporation, M-C Power, International Fuel Cells and Westinghouse Electric. Industry-wide associations such as the Gas Research Institute and the Electric Power Research Institute (EPRI) have also spearheaded important development efforts and demonstration projects.

International Fuel Cells is currently producing 200-kilowatt phosphoric acid fuel cell power plants. Over fifty of these units have been sold to various organizations, mostly in the United States and Japan. IFC is also supplying the fuel cell stacks for a demonstration plant in Italy as well as for the 11,500 kilowatt plant operated by Tokyo Electric Power Company.

Westinghouse is in the final phase of its development of an air cooled phosphoric acid fuel cell technology. In a cooperative government/industrial funded program, this technology has advanced to the point of demonstrating its commercial readiness. Using private sector funds exclusively, a three year project has been undertaken to integrate a 400 kW air cooled phosphoric acid fuel cell module into a European industrial plastics plant. In this application, excess hydrogen produced as a by-product in the plastic manufacturing process will be used in the fuel cell to produce the DC power required for the plant's electrolysis operations. Industrial applications of this type are abundant in the United States and represent a unique commercial opportunity for the technology, thereby reducing the power demands of this energy intensive industry.

Molten carbonate fuel cells are also being developed by International Fuel Cells, Energy Research Corporation, and by M-C Power Corporation. The Energy Research Corporation plans a 100-kilowatt field test of these cells in conjunction with The Pacific Gas and Electric Company and with support from EPRI. M-C Power is exploiting technology developed by the Institute of Gas Technology which also has a working relationship with a Dutch consortium to design molten carbonate fuel cells.

The work performed at the Westinghouse Electric Corporation is indicative of the substantial effort and financial resources fuel cell technology is receiving in the United States.

The tubular solid oxide fuel cell and generator module was developed by Westinghouse and today the Corporation is committed to the development and commercialization of solid oxide cells for the clean and efficient generation of electric power.

For more than two decades, Westinghouse has been developing the materials and establishing the processes that will be necessary to commercialise solid oxide fuel cell technology.

The Westinghouse solid oxide fuel cell is clean . . . compact . . . and highly efficient.

A 200 kilowatt module fits into a small room. It's safe, quiet and pollution free . . . so it can be placed conveniently near the load it serves without the need for long transmission lines.

The solid oxide fuel cell power plant can have an electrical efficiency over 60 percent . . . more efficient than any other conventional power system . . . and 50 percent more efficient than a modern steam-turbine generator.

The solid oxide fuel cell has an excellent ability to follow the load and handle overload situations while remaining at high efficiency. The air and fuel ratios are simply adjusted, just like using the gas pedal in a car.

The cell operates efficiently at atmospheric pressure at temperatures that approach 2000 degrees fahrenheit to produce electricity from fossil fuels such as coal-derived fuel gas or natural gas. Exhaust gas temperature of the solid oxide fuel cell generator, at 1000 to 1600 degrees, make it attractive for cogeneration applications and for use in bottoming cycles in all-electric applications.

Since the nitrogen in the air stream is separated from the fuel when the fuel is being consumed electrochemically, the formation of nitrogen oxides is retarded. This should enhance the commercialisation of solid oxide fuel cell technology, particularly in light of ever-changing and more stringent environmental emissions standards around the world.

The Company has already achieved several important milestones toward commercialisation of its solid oxide fuel cell.

- The 3-kilowatt systems built by Westinghouse and operated by Tokyo Gas and Osaka Gas demonstrated many of the key advantages of solid oxide cells. Availability was extremely high ... at 98 percent. Emissions were low; for example, nitrogen oxide emissions were no more than two parts per million. And noise levels were less than 60 decibels ... roughly equivalent to normal conversation.

If similar levels of nitrogen oxide emissions are achieved in larger units, they will be several orders of magnitude below the level gas engines are projected to achieve by the year 2000.

In addition, solid oxide fuel cells produce far less carbon dioxide -- the primary factor contributing to global warming -- because of their higher efficiency.

- The units operated by Tokyo Gas and Osaka Gas, and by a demonstration conducted by the Tennessee Valley Authority, or TVA, exhibited the ease of installation, unattended operation and simplified maintenance in the field.
- The TVA project also illustrated the very rapid load-following capability characteristic of solid oxide fuel cells.

A 20 kW system has recently been put on test under the U.S. DOE/Westinghouse Program, using natural gas directly from the pipeline.

25 kW systems are under construction for operation by Japanese utilities.

The total expenditure for the two Westinghouse fuel cell development programs, i.e. phosphoric acid and solid oxide, is approaching \$200,000,000 and is not yet half finished.

I hope to have shown that development of fuel cell technology is being carried out by competent organisations throughout the world. Indeed we are in a race to lead these technologies with foreign organizations, well funded by governmental, quasi-governmental, or institutional interests. These programs are very expensive, technologically risky, and require a long term staying power.

It is in that light that increased, long-term and consistent government support is needed in order to maintain our current slight technological edge.

Mrs. LLOYD. Thank you very much, Mr. Dollard. Have U.S. utilities, you spoke of their involvement with the Japanese, have they been enthusiastic about the potential of phosphoric acid fuel cells for power plant generation?

Mr. DOLLARD. My activity with the Japanese has been with the solid oxide fuel cells. The Japanese have a very good phosphoric acid program, of course, of their own. They are very, very interested in high efficiency, and they are very interested in technologies that have low pollution. They have 100 million people on a very small bit of territory. Of course, the population areas around Tokyo and Osaka are very dense. There is a lot of energy being generated and a lot of pollution being generated. So, they are very anxious to develop low-polluting technologies and, of course, since they have no indigenous fossil fuels, to speak of, they are very, very interested in high efficiency.

Mrs. LLOYD. Are U.S. utilities enthusiastic about this potential?

Mr. DOLLARD. I wish they were as enthusiastic as the Japanese. As I think we heard here before, most of our utilities are looking for supporting technologies when they are a little closer to commercialization than we are. Therefore, it seems that the Japanese look out a little bit further, and are willing to support technology a little bit further out in time than our own utilities are able to support.

Mrs. LLOYD. Mr. Sanderson, if we were to refer the three types of fuel cell developments, phosphoric acid, molten carbonate, and solid oxide as one, two, and three generation technologies, what are the increased benefits of each? What does one offer over the other one in terms of efficiency or where they can be located?

Mr. SANDERSON. I think Mr. Dollard might want to comment on the phosphoric acid, but I would say from my point of view, the advantages of the molten carbonate and the solid oxide are that these types of fuels operate at a high temperature, so that when you get heat produced in the fuel cell, which is natural by-product of making the electricity, in the molten carbonate and in the solid oxide fuel cells, you have the advantage of having very high quality heat that can be used either to generate more electricity or to provide processed heat, or to provide heat for air conditioning, space heating or water heating.

Mrs. LLOYD. Do you feel they're more versatile or applicable to other various areas of the country?

Mr. SANDERSON. I would say from my point of view, we're committed fully to the molten carbonate, because we believe that the advantage of being able to operate at the higher temperature will be very important, particularly to our utility customers.

Mrs. LLOYD. Mr. Schora, would you like to comment on that?

Mr. SCHORA. Yes, Madam Chairperson, I feel that the molten carbonate has great potential because it basically uses relatively inexpensive materials of construction. Because of the higher temperatures, the electrodes, an important part of the component are made of nickel and hopefully we can convert that to copper in the next two years, which is relatively inexpensive. As one goes down in the temperature of operation, not only do you use the ability to recover heat, as Dr. Sanderson mentioned, but you also have to go to

rather exotic catalysts to get the so-called electrochemical reaction to go.

Mrs. LLOYD. Mr. Morrison.

Mr. MORRISON. Gentlemen, one of the efforts that we're going to try to make with this subcommittee is to help out the National Energy Strategy by coming up with a process by which we guide the research and development investments in the future. I guess your panel is a good one, since you are not at or approaching commercialization yet to maybe ask a couple of basic questions. That is, at what point is it logical to ask for private industry participation in the development of technologies, like fuel cells? Is there a logical point that you can say that it's beginning to look good enough and someone should be willing to invest in this for commercial purposes?

Mr. SANDERSON. If I were to respond to that, I would say that as a technology moves towards commercialization, clearly there should be increasing industrial participation. It's a little hard to draw a line which is absolute, because the amount of cost-share that you can expect industry to provide is very well related to the risks and the overall costs from the current state to development. As I think I mentioned in my oral testimony, we are currently contributing 30 percent cost-share to our molten carbonate fuel cell program. We also have, as part of the Clean Coal Technology Program, a gasification project underway in the State of Illinois, to which we are contributing more than 50 percent. On both of those, I think we took a hard look at the risk, the cost involved, and decided that the cost-share was worth it. At the moment, I would say that the risk in the fuel cell technology is still sufficiently high to where we need substantial government contributions.

If you move back upstream, look at some of the other technologies we are currently working on for coal-fired energy production, we are hoping that we can get government cost-sharing more in the neighborhood of 80 percent government, 20 percent ABB. These are technologies which are even further from the market place and even further from commercialization. The cost of money is important to a private company. We have to figure that if we are five or ten years away from commercialization, the carrying cost on the money before we can realize a return is such that, essentially, it has to be written off. So, there are a number of factors.

I believe industry, for the most part, can begin to contribute at any point beyond the more fundamental research stage. I think that contribution has to shift over time. I believe there is a government roll right up to the point where there has been a demonstration at a large enough scale that industry and the customer can have confidence that the technology will work.

Mr. MORRISON. Do either of you gentlemen wish to differ with the doctor?

Mr. SCHORA. No, I wouldn't differ with him at all. I would add that one of the problems I think that has occurred in the past, and I hope it doesn't occur again, is that I think in the cost-sharing on the Government's part, at times it's ended just a little too soon. In other words, industry quite hasn't gotten confidence in the technology to the point of going it alone, so to speak. In order to start up a fuel cell manufacturing facility, you have to get quite a few orders

out ahead of you to make sure that your costs are appropriate. If the technology hasn't been adequately demonstrated, then there can be a problem with, say, some hesitancy in industry to proceed with purchases. You can wind up in a spot where you find yourself short of funds.

I think this might have happened in the phosphoric acid program. We are requesting or planning in our program for seven demonstration units over the next four to five years. This is very important to instill confidence in the industry, who is going to buy these. I think during that period, some percentage of cost-sharing by the government is certainly very, very important.

Mr. MORRISON. Mr. Dollard.

Mr. DOLLARD. I would think that possibly one of your concerns is that these processes are drawn out longer than necessary to bring in more and more government funds. I've been brought over from the commercial part of the company to do this work. I'm an engineer, I'm not a scientist. I know one thing for sure. As soon as I know that we're going to be commercial, I know it's not going to be long before somebody else realizes that, who's competing with me. At that point, I know that I got to step on the gas and I got to go all out and make it happen, with my own funds. Because if I'm not, somebody is going to beat me to it. Then all the time and all the effort over all these years, as far as I'm concerned, is going to be wasted. So there comes a time when we realize that we've got the produce, we've got the customers, we've got the price. Then we will start putting big money into manufacturing facilities. I think when you see that, we'll know that so and so feels he's ready to go. He's going to go whether there is government support at that point or not.

Mr. MORRISON. You almost make a case for government to discontinue and then you, as competitors, will leap out ahead of that with your own money at the time when you feel you are ready to make a move.

Mr. DOLLARD. I think there comes a time, if you look at the cost of various developments, and how it goes along, it starts out with a little research and it goes up with development. Then, suddenly, the expenditures really get big. That's when you start going into your manufacturing facilities and the final engineering, etc. The reason why your question is so difficult is what is that point in time. It's a different point, depending on what the technology and the uncertainty of the technology, and the uncertainties of the customer base. Who would have thought in 1973 that the nuclear business was going to be finished for 20 years, or however long it has been finished. I certainly wouldn't have. There are big uncertainties that come from the environment, and from other things, that we don't understand.

But when the time comes, you have to make that decision and you have to move. Because if you don't, we're not the only people in the world developing fuel cells. While we'll be competing with each other, we know that if one of us gets way out, it is going to be heck for the other one to catch up. It's the same thing with the foreigners. If they get ahead of us, it's going to be very tough for us to catch them. So you've got to take your shot at it. When you see

the probabilities are that you're going to be successful, you've got to move then.

Mr. MORRISON. I think we want to design some sort of a process so you have an assurance, as you work on a technology, that a cost-sharing program is in place that isn't going to evaporate on you, but at the same time, have the flexibility you described. I'm not sure how we get to that magic point.

Mr. DOLLARD. I think you need the flexibility. As I'm going along and I start falling on my face, you need the flexibility to drop me. You have to constantly keep watching how we're doing.

Mr. MORRISON. This is not so much a question, well, yes, let me make it a question. I sense that your technology, among all of those we're visiting and will be as we go through this authorization cycle, is one that maybe helps solve one of our other problems; that is, long distance transmission systems. If fuel cells really work, you could virtually have them in your neighborhood. I understand that's one of your strengths.

Mr. DOLLARD. Yes. I think that's common. I think we'd have to say that's common to all fuel cells.

Mr. MORRISON. That is indeed a plus, Madam Chairman. Thank you very much.

Mrs. LLOYD. Thank you. Mr. Fawell.

Mr. FAWELL. Thank you, Madam Chairman. Mr. Schora, you had indicated that industry was also cost-sharing in addition to the federal assistance that you're getting. Could you expand on that a bit?

Mr. SCHORA. Yes. We're working very diligently with industry, with several utilities, with the Electrical Power Research Institute and the Gas Research Institute to come up with a plan and the funds to help see us through the stage of the demonstration to commercialization. We are voluntarily now getting funds from the public service company in New Jersey, Florida Power in Florida, with no promise of any returns to them. San Diego Gas and Electric is involved. So-Cal. Gas is involved. Unocal is involved. There is a tremendous amount of industry. As I mentioned briefly in my testimony, we have put a group together known as ACT, which in effect is to bring all these organizations together so that we can formulate a plan, number one, to come up with a design of a system which is usable to them, which fits their needs; and number two, to identify better the teams that we need to carry these through demonstration. There is, I think, a very interested group in industry, who wants to put forward in collaboration with the government to see this to commercialization.

Mr. FAWELL. Are they contributing presently then?

Mr. SCHORA. Yes, sir, they are. They are contributing to this particular contract that we now have with the Department of Energy.

Mr. FAWELL. What percentage, roughly, do you know?

Mr. SCHORA. Well, it was mentioned that our program is a program in which we're receiving or we're contributing 30 percent cost-sharing. ABB is cost-sharing 30 percent of the funds that they're receiving from the government, and we're providing, M-C Power is providing some small amount of cost-sharing. Because we are a small fledgling organization, these other industries have come in to give us assistance to get us up to the 30 percent cost-sharing level.

Mr. FAWELL. So they're a part of the 30 percent.

Mr. SCHORA. Yes, sir. There is work also going out beyond that contract, specifically in the second demonstration, which we plan to have in the San Diego area. This is a group totally outside of the DEO Program.

Mr. FAWELL. Yes. It would seem to me that you do have this added industry participation as a plus and it would be an added factor that as long as that interest is there, the idea of when do you reach the commercialization point, at least, that's a little sign post along the way, it would seem to me. What about the Japanese, where are they, roughly, would you say in reference to reaching commercialization or a demonstration of commercialization, as compared with, I gather the two of you, ABB and M-C Power Corp., the partners in this? Are they miles ahead of us, roughly equivalent, or where?

Mr. SCHORA. I would say, Congressman Fawell, that they are basically, from a technological standpoint, I would say they are slightly behind us. From the standpoint of building larger hardware, namely larger power producing stacks, the larger balance systems, they are ahead of us. Right now, we estimate, as was mentioned by Mr. Dollard, that their program in the molten carbonate area is probably over \$100 million a year. This obviously will have impact on whether they win or we win. I think with adequate funding, if we wait our program out, we can clearly win this race. But it's an area that the Japanese see not only for use within Japan, but they see this as a very big export product, probably not as large as cars, but they see it as a big one.

Mr. FAWELL. Fine. Thank you very much.

Mr. SCHORA. You're welcome, sir.

Mrs. LLOYD. Thank you very much, Mr. Fawell.

I want to thank our witnesses and I want to thank the staff for putting this hearing together. We will be submitting questions in writing for the record.

Thank you very much.

[Whereupon, at 5:00 p.m., the subcommittee adjourned, to reconvene at the call of the Chair.]



APPENDIX I

THE HONORABLE TERRY L. BRUCE
SUBCOMMITTEE ON ENERGY
MARCH 5, 1991

THANK YOU, MADAME CHAIRWOMAN. I WANT TO TAKE THIS OPPORTUNITY TO EXPRESS MY DISAPPOINTMENT IN THIS YEAR'S DEPARTMENT OF ENERGY BUDGET REQUEST FOR ENERGY RESEARCH AND DEVELOPMENT. IT SEEMS THAT EVEN THOUGH THE PRESIDENT HAS TAKEN THE TIME TO PUT TOGETHER A NATIONAL ENERGY STRATEGY, HE IS ERODING ANY SUPPORT HE MAY RECEIVE FROM PEOPLE LIKE MYSELF, BY PROPOSING AN ENERGY RESEARCH & DEVELOPMENT PROGRAM WHICH I CONSIDER INADEQUATE.

IT IS UNFORTUNATE THAT THE ADMINISTRATION DOES NOT SEE THE IRONY IN PUTTING OUT A NATIONAL ENERGY STRATEGY WHICH IS SUPPOSED TO SEE THE UNITED STATES REDUCE ITS DEPENDENCE ON FOREIGN OIL WHILE AT THE SAME TIME SLASHING RESEARCH AND DEVELOPMENT PROJECTS DESIGNED TO HELP THIS COUNTRY TOWARD THAT GOAL. I AM PARTICULARLY CONCERNED WITH THE FUNDING OF FOSSIL FUEL RESEARCH AND DEVELOPMENT.

FURTHERMORE, I AM DISTURBED BY THE SUGGESTION THAT CLEAN COAL TECHNOLOGY FUNDS BE TRANSFERRED TO THE FOSSIL FUEL RESEARCH & DEVELOPMENT PROGRAM. BECAUSE OF THE CLEAN AIR ACT AMENDMENTS PASSED LAST YEAR, THERE IS A PERFECT OPPORTUNITY FOR THIS COUNTRY TO SUPPORT THE DOMESTIC COAL ECONOMY WITH RESEARCH FUNDS. I LOOK FORWARD TO THE OPPORTUNITY TO SPEAK WITH DR. BROMLEY AND QUESTION HIM AS TO THE LOGIC BEHIND THIS PROPOSAL.

LASTLY, LET ME SAY THAT AS A MEMBER OF THIS COMMITTEE I LOOK FORWARD TO COMING UP WITH A FAIR AND REASONABLE APPROACH TO THE DEPARTMENT OF ENERGY'S BUDGET FOR FISCAL YEAR 1992; THE FOSSIL FUEL RESEARCH AND DEVELOPMENT PROGRAMS ARE JUST THE BEGINNING.

THANK YOU.

JERRY F. COSTELLO

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SUBCOMMITTEE ON ENERGY

**DEPARTMENT OF ENERGY FY 1992 BUDGET REQUEST FOR FOSSIL FUEL
RESEARCH AND DEVELOPMENT ACTIVITIES**

MARCH 5, 1991

Madame Chairman, today we welcome our very distinguished witnesses to discuss the Department of Energy's FY 1992 budget request for fossil fuel research and development activities.

As I stated last year, and believe today, as we consider the problems of increased energy demand, energy dependence and environmental phenomena such as acid rain and global warming, we must investigate the potential of fossil energy as an alternative source of electricity.

In order to determine this, it is imperative that we find what the appropriate level of funding should be for these programs. It is my belief that we must seriously consider the use of fossil fuel as we work towards a comprehensive national energy policy. However, it is disturbing to see the 51% decrease from FY 1991 in this years budget request, and I must question if it is feasible to work with such a drastic decrease.

I also must question the necessity of transferring 150 Million out of the Clean Coal program to the Fossil R&D program.

Madame Chairman, as we consider the level of funding and coal reserves, I look forward to hearing from our witnesses and I thank you for calling this hearing.

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APPENDIX II

TESTIMONY OF

**DR. MONTAZ N. MANSOUR
PRESIDENT OF
MANUFACTURING AND TECHNOLOGY CONVERSION
INTERNATIONAL, INC.**

BEFORE THE

**SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES**

Madam Chairman, distinguished members of the Subcommittee, I am Dr. Montaz N. Mansour, President of Manufacturing and Technology Conversion International, Inc. I appreciate the opportunity extended by the Subcommittee to testify before you.

In my testimony I will address the following topics:

- I. Inform the Subcommittee of recent technological developments, implications and funding needs.
- II. Present policy issues and recommendations for consideration by the Subcommittee.

I. RECENT TECHNOLOGICAL DEVELOPMENT

I wish to brief the Committee on the technology of resonant pulse combustion, its applications and the additional FY-92 funding needs for its development.

Resonant pulse combustion is a combustion process that promotes combustion-induced oscillations to effect a large number of process benefits. The application of resonant pulse combustion within the energy program encompasses a number of revolutionary technologies for coal utilization, waste-to-energy applications, and industrial processes. Within the DOE Fossil Energy and Small Business Innovative Research Programs, resonant pulse combustors are employed in a number of cornerstone applications as described below.

Slagging and dry ash rejecting pulse coal combustors are being developed under the DOE/PETC program for the use of coal, instead of oil and gas, for industrial and commercial boiler retrofit applications. In this application the potential is simply enormous due to a number of considerations. Industrial and commercial boilers consume significant amounts of oil and gas in this country. Given the appropriate advanced coal combustion technology, most such boilers could be retrofitted to burn coal in an environmentally clean manner. This will significantly reduce oil and gas consumption while protecting the environment. Results from the current Pulse Coal Combustor program at DOE/PETC have established that standard grind, high ash and high sulfur coals can be used with this technology, achieving a 99.9+% carbon conversion, less than 180 ppm NO_x production, more than 75% sulfur capture and 97+% ash rejection in the form of slag or dry ash. Thus, this technology has the promise of being a cornerstone of firing coal, instead of oil and gas, in industrial and commercial boilers with superior environmental performance without the expense of first beneficiating the coal. The technology also has significant potential for export of both equipment and coal to Europe and other oil- and gas-dependent allied nations.

The slagging pulse coal combustion technology for industrial boiler retrofit applications was successfully scaled up to 15 MMBtu/hr in firing rate and now requires \$1.6 million in additional FY-92 budget for field testing. In the case of the commercial, non-slagging, pulse coal combustor technology

for retrofit of commercial-size boilers (2 - 5 MMBtu/hr), this program requires approximately \$1.4 million in additional funding obligation by DOE to complete the work under the contract now in force. It is our understanding that there is no funding in the current FY-92 budget submission for either the Industrial or the Commercial elements of the advanced coal combustion program. This will terminate the opportunity for harvesting the benefits of these technologies and a loss of the previous investment made by the taxpayer in a development that totals approximately \$6.5 million since 1984. I strongly urge the Committee to provide for the harvesting of these technologies and to provide specific language designating these technologies to ensure that funding does not end up with foreign companies. I will discuss the issues associated with foreign-owned companies in the latter part of my testimony.

In programs under the direction of DOE/METC, resonant pulse combustion is being employed for advanced gas turbine/direct coal-fired combustor island applications, advanced atmospheric fluidized bed hybrid combustor systems, and second-generation combined-cycle pressurized fluid-bed systems.

In the case of direct-fired gas turbines, the technology employs standard grind, high ash, high sulfur coal as the fuel of choice. Ash and sulfur removal take place in the compact combustor island made possible by innovative use of the process of resonant pulse combustion. Given the success of this development effort, standard grind, high ash, high sulfur coal can be used in direct-fired gas turbines and combined-cycle gas turbine systems, revolutionizing power generation in this country and again minimizing the need and cost of front-end, deep coal beneficiation. Capital and operating costs of such systems are simply dwarfed by present-day gasification combined-cycle plants. The program needs \$2.5 million in additional FY-92 funding for this extremely important development.

This technology, which came out of the DOE Small Business Innovative Research program under the supervision of DOE/METC, is being pursued with the research support of the Pennsylvania State University, and engineering and equipment test support by Solar Turbines Incorporated of San Diego, California, a division of Caterpillar.

The advanced hybrid pulse combustion/atmospheric fluid-bed system employs a pulse coal combustor that is down-fired in an atmospheric fluidized bed. Coal fines, which are the source of problems in fluid beds, are burned in the down-fired pulse combustor. The oscillating jet flow of the down-fired pulse combustor is employed to enhance the performance of the fluid bed which only burns large coal particles. The hybrid system, therefore, provides a superior combustor system to burn unclassified, crushed coal in an environmentally acceptable manner. The technology lends itself especially well to small systems in the size range of 10,000 to 50,000 pounds/hr of steam, which is not only a significant target for the displacement of oil and gas in this country, but resolves the long-standing issues of scale-down of presently available fluid-bed systems. Even in present-day large commercial systems, the technology can be used to resolve the inefficiencies and cost issues presented by their inability to burn coal fines. The technology is now entering the field-test stage and requires \$3.3 million in additional FY-92 funding.

Concepts employed for the direct-fired gas turbine system and for the hybrid pulse combustor/atmospheric fluid-bed combustor have further been combined to give rise to an advanced, second-generation, pressurized, fluid-bed power-generating system fired with unscreened crushed coal. In the pressurized, fluidized bed technology, a "trim" pulse combustor island, fired with the coal fines, is employed to increase the turbine inlet temperature while removing ash and sulfur pollutants. This technology is initially targeted for mid-sized combined-cycle power generators and cogeneration equipment in the 25 to 50 MW_e size range. The technology is currently directed to displacement of similar size units now being fired with oil and gas. Electric utility size systems will be based on scale-up of the technology to the 250 MW_e size range. This technology is in the early stage of development and requires \$1.2 million in additional FY-92 funding.

It is with a great deal of pleasure that I also report to the Subcommittee a success story of the DOE/Small Business Innovative Research (DOE/SBIR) Program. The technology being reported here has a vast spectrum of end-use applications with staggering implications and benefits to both the National energy economy and our environment. The thermochemical reactor technology and related processes provide for waste-to-clean energy conversion, steam reforming of coal fuels producing hydrogen-rich synthesis gas, mild gasification of coal to produce coal-derived liquid fuels, surface retorting of oil shale, surface retorting of tar sands, and steam reforming of heavy (residual) hydrocarbon liquids.

Synthesis gas produced from the various feedstocks such as waste, lignite and subbituminous coals and heavy residual liquids can be used to produce light liquid fuels such as methanol and gasoline. The following is a partial list of the technology applications intended to illustrate the vast spectrum of end-uses and to provide an appreciation for the staggering implications of the technology to the National energy economy and the environment.

1. Paper Mill Spent Liquor Recovery:

This application of the thermochemical reactor technology was pursued in cooperation with the Weyerhaeuser Company. The development yielded the only process in the world for recovery of energy and chemicals, without smelt formation, from spent liquors in pulp mills. The technology was tested successfully at the PDU level with Kraft, sulfite, BCTMP, and soda spent liquors. In this application the spent liquor is steam reformed in the thermochemical reactor and a hydrogen-rich synthesis fuel gas is produced. The chemicals in the liquor are recovered in the form of sodium carbonate solids from the thermochemical fluid-bed reactor. In the case of sulfur-bearing spent liquors, the sodium carbonate is used in a solution to recover the sulfur by scrubbing the product gas, thus recovering the chemicals. The clean product synthesis gas can then be used to fire a combined-cycle or cogenerating gas turbine or a boiler or be used to produce liquid fuels such as methanol. The technology also provided practical solutions for abatement of serious pollution problems found in pulp mills relating to sulfur emissions, NO_x emissions, and dioxins. The technology application is now at the field test stage where a 50-tons/day plant is being built to be tested at the Weyerhaeuser pulp mill in New Bern, North Carolina. To complete this

field test program, \$3.2 million is required in FY-92 budget that is not presently in the current budget submission. This is required to meet the DOE funding obligations under the current cooperative agreement and to fund the supporting laboratory-scale process development unit activities. We are in a race with foreign competition from a Swedish company that is pursuing a plasma partial oxidation process. The Swedish technology is inferior to ours but is being steadily funded for field testing by the Swedish government.

2. Industrial Sludge Conversion:

A great deal of industrial sludge which contains carbonaceous and hydrocarbon material and some containing chlorinated hydrocarbons is now being landfilled in this country. The thermochemical reactor technology being reported here was tested successfully at the PDU scale demonstrating processes for steam reforming industrial waste sludges to produce a clean hydrogen-rich synthesis fuel gas from such wastes. Sorbents were used in the fluid-bed thermochemical reactor to remove sulfur and chlorine pollutants. Dioxins and chlorinated hydrocarbons present in the waste sludge were steam reformed and destroyed. By using these vast amounts of waste to produce clean energy, we are able to offer a lasting solution to this country's energy and environmental problems. The clean product synthesis gas can be used in a wide spectrum of applications including liquid fuel production (methanol and gasoline), a source of hydrogen fuel gas, hydrogen for refinery feedstock to enhance the production of light liquid fuels from petroleum and firing gas turbine combined-cycle and cogenerating systems. I must also note that burning hydrogen and hydrogen-rich product gas reduces significantly our problems with NO_x production.

The California Energy Commission provided \$500,000 in cost sharing for a field test of converting an industrial waste sludge to clean hydrogen-rich gas at a site in southern California, where environmental issues are at the forefront of state and local policies. Funding from DOE was not available within the 1991 budget and I urge the Subcommittee to consider \$1.2 million in additional FY-92 budget for the support of field testing this extremely important application of this technology.

3. Sewage Sludge and RDF Conversion:

Under the EPA Small Business Innovative Research program, Phase I, steam reforming with pollutants capture was successfully tested at the PDU level. The thermochemical reactor technology has shown that clean hydrogen-rich synthesis gas can be produced from sewage sludge and from garbage or refuse-derived fuel. As I mentioned in the case of industrial sludge conversion, this technology will also produce clean gaseous and liquid fuels from these wastes.

In this country, sewage plants are paying as much as \$350/ton (on solids basis) to dispose of sewage sludge and upward of \$80/ton is being paid to landfill garbage. We need energy and we have a problem with the environmental impact of our waste. This technology provides a lasting solution to both our energy and environmental problems. We anticipate funding under Phase II of the EPA/SBIR program to continue the work on the sewage sludge process;

however, an additional \$1.2 million in FY-92 funding for DOE is needed to field test, at 6 tons/day pilot-scale, the RDF application. The technology for the RDF is now ready for field testing.

4. Steam Reforming of Lignite and Subbituminous Coal:

Under the DOE/SBIR program, steam reforming of lignite and "young" coals was successfully tested. The U.S. has enormous lignite and subbituminous coal resources that are underutilized. Lignite, for example, is found in Texas, Louisiana, and the Northwest. Lignite contains 30 to 50% moisture and, therefore, is not significantly used. Nevertheless, in steam reforming the moisture is not a penalty, since the steam-to-carbon ratio required to produce hydrogen-rich synthesis gas from this process exceeds the moisture content of the lignite. As discussed earlier, the clean hydrogen-rich gas can be used as fuel or used to produce liquid fuels such as methanol and ultimately gasoline. The highly reactive nature of lignite and subbituminous coals together with the moisture content of such resources makes steam reforming of such fuels for production of clean, hydrogen-rich gaseous and liquid fuels not only a logical means of utilizing these resources, but a major element in any strategy for our energy independence and environmental goals of our Nation.

At the present time we anticipate funding under Phase II of the DOE/SBIR program and therefore no additional funding is needed in FY-92. I thought that it is important, however, to brief the Subcommittee on this application and its enormous potential in alleviating our dependence on foreign oil.

5. Mild Gasification of Coal:

In the case of bituminous coals, mild gasification can be employed to extract from the coal hydrocarbon liquids that can be further refined. A large amount of char, however, is also produced in the process that must be utilized before economic viability can be achieved with mild gasification. To this end, DOE/METC funded a project to test the thermochemical reactor technology, on which I am reporting here, in two processes. First being indirectly heated mild gasification of coal to maximize liquids yield. Second, char steam reforming to produce hydrogen from the char produced by the mild gasification of coal which is discussed below.

6. Steam Reforming of Char and Heavy Liquids:

As I mentioned earlier, the char by-product of mild gasification was successfully steam reformed to produce hydrogen. In addition, heavy liquefaction bottoms and heavy residual bottoms from petroleum refineries were also steam reformed to produce hydrogen. The hydrogen produced from these low-grade fuels (char and heavy bottoms) is to be used in further hydrogenation of coal liquids and for consumption in hydrocrackers in petroleum refineries to increase the yield of light liquid fuels such as gasoline. Synthesis gas produced by the process is shift reacted to increase the yield of hydrogen, otherwise it can be directly used as gaseous fuel or to produce methanol or ultimately gasoline.

7. Oil Shale and Tar Sands:

Data acquired to date on the mild gasification of coal suggest that the indirectly heated thermochemical reactor technology may be well suited for surface retorting of oil shale and tar sands. Funding from the DOE/SBIR program is now being sought to establish the feasibility, process conditions, and reactor throughput in retorting oil shale employing the thermochemical reactor technology.

Preliminary cost estimates and economic analysis indicate that this technology has significant potential in rendering the extraction of liquid fuels from oil shale economically viable. This is a very important application of this technology, particularly when most energy companies are losing interest in oil shale.

No additional funding is needed in the FY-92 budget since we anticipate that adequate funding at this stage will be available from the DOE/SBIR program. Nevertheless, given the appropriate technology for liquid fuel extraction from oil shale, the opportunity for displacement of petroleum is large indeed.

8. Thermochemical Conversion of Biomass Waste:

The reactor technology has also been successfully tested with a wide spectrum of biomass feedstock including rice hulls, pistachio nut shells, agricultural prunings, wood chips, etc. The product synthesis gas produced is quite similar to those discussed above including its use for production of liquid fuels.

With these examples, it is clear that this technology has a vast potential in dealing with both our energy and environmental problems. It is also extremely important to note that the technology is aimed at the kernel of our energy needs because it yields clean gaseous and liquid fuels from renewable (including waste) and vast non-renewable energy resources of this country. Incineration of wastes, for example, yields heat that can be used to produce steam and at best electricity from steam at low efficiency but with the potential for air pollution. The technology I am reporting about produces clean synthesis gas fuel that can either be directly used as gaseous fuel or used to produce light liquid fuels.

This technology was initially born under the DOE/SBIR program in 1985 for biomass gasification and is now entering the full-scale field test and commercialization stages. This technology also employs pulse combustion but applied to an indirectly heated thermochemical conversion reactor.

II. POLICY ISSUES AND RECOMMENDATIONS

In this part of the testimony, I wish to present the Subcommittee with some policy issues and provide some recommendations with respect to these issues.

We, the workers in the trenches of invention and technology development, have good news and have something irreplaceable to offer. We also feel an awesome obligation to our country because we are the energy technologists that must deliver technology to ensure our nation's security, economic well-being and real might. All are required to sustain the only real success in the history of mankind; the United States.

We therefore have an obligation to ensure that these technologies will in fact serve the United States in finding a true and a lasting solution to our economic and national security needs, in peace time, just as the aerospace and military technology have served this nation well, in fact beyond expectation, at the time of a crisis and a military conflict.

We were all reminded brutally one more time of our need to solve our energy problems. This is our third rude awakening within the last two decades and I sincerely hope we do something about it this time.

The greatness of the United States is really founded in technology. This is true whether it is military might, economic might or even the might of our free society in its ability to remain free, thus leading the world into freedom and prosperity.

Our nation won the cold war and through your support and with the superb performance of our men and women in uniform, you also paved the way for sustaining the economic well-being in the free world. In order to implement the people's vision for our nation and the world, we must call again on our technology army to revive our true might for lasting solutions to deal with the new economic war that is about to replace the cold war in a free world economy. This is the next order of business that may not look like a crisis, compared to the one we just went through, but it is just as intense and potentially more ominous.

A pivotal area upon which our economic welfare and ability to retain our greatness and way of life, while competing with Germany, Japan and new democracies in the eastern bloc nations, will be energy.

Enhanced oil and gas production is a near term, but, at best, an interim measure. The real and lasting solution lies in production of clean energy from coal and waste streams with continued efforts in conservation.

In our vision, we see our company providing equipment to convert waste and coal resources to useful forms of clean energy, and exporting capital-intensive equipment made in the United States (for a change) to friendly nations overseas. This would have a multitude of benefits to our economy: 1) the reduction of oil imports (and in time eliminating it), 2) export of capital-intensive energy equipment, 3) reduction of our balance of trade deficit, and 4) the creation of a vast technology and industrial (manufacturing) base in the United States to meet the challenges of the fierce economic, albeit peaceful, war in the new world competitive environment.

At times, when my colleagues and I ponder such matters, we have a deep concern about the decline in attention given to the nation's real might, the technologists of the U.S. The scientists and engineers who gave their all to the aerospace program in the 1960s found themselves without a job during the aerospace depression that followed. That group of people identified silently with the nation's Viet Nam veterans. They have done such a good job that they lost their jobs. Many of them left engineering and science and went into real estate brokering, insurance sales and the like. Some heeded the call for dealing with the new national challenge in energy and some found jobs in the defense programs.

The silent ripple, which went totally unnoticed by our society, led to the refusal by our young people to go to engineering or scientific schools: they have seen what happened to their parents and relatives and decided it is not worth it.

The peace-time army for the United States in the new world competitive environment with the hopefully continued systematic democratization of the world's nations will be the technologist. New technology for waste conversion to clean energy and for production of clean energy from our vast coal resources is simply a pivotal must.

Energy will remain a foundation for the economy of the industrial world, and capital intensive energy equipment, based on advanced technology, will remain of profound importance in matters of balance of trade for many years to come. The importance of the energy equipment industry to jobs and establishment of an industrial/manufacturing base in the U.S. is also an essential ingredient. Simply put, energy commodities, technology and equipment will continue to correlate to large sums of money with first, second and third order ripples throughout the economies of civilized industrial nations.

My colleagues and I, who are technical people that run a small, high technology business, often discuss such matters, and as a result we feel there is an urgent need to inform our leaders about what needs to be done. In the following, I offer some thoughts for the Subcommittee to consider.

1. U.S. Federal R&D Funding of Foreign-Owned Companies:

While a primary objective of Federal R&D funding is to enhance the technological position of our Nation in a highly competitive world, small, high-technology U.S. companies have been losing to large, foreign-owned companies. This is particularly serious since the bulk of the innovation in the U.S. is provided by small companies. We do not understand that. The technology drain is already underway and there is no need for Federal assistance to foreign-owned companies to augment this drain. Small companies are not multinational and most look to the United States as the only home they care about. In addition, small business is the largest employer in the U.S. where the technological and entrepreneurial might of the U.S. is vested. There should be legislation to provide our own small companies a fair chance to provide the Nation with what it needs. This is very serious in the new highly competitive world environment. We have anti-trust laws to protect the people of the U.S. from monopolies by U.S. firms, but there is no protection

against foreign take-over of our future. We are exporting our future with American tax dollars paying for research and development at foreign-owned companies.

2. Cost Sharing on R&D Programs:

This is now becoming another instrument for discrimination against small business. While on the surface it appears that cost sharing is a good idea, in practice it is not useful at all, if not a negative policy. First, large companies that obtain R&D funding are very expensive with high overhead and G&A costs. A small business almost always can get the same job done at one-fifth to one-tenth the costs of these large companies. So even with 50% cost sharing, the taxpayer still loses - even if all the cost sharing is in cash. In-kind cost sharing makes this even worse because resources claimed as cost sharing are often not real. More importantly, the measure shuts off small companies where the real technology innovation and entrepreneurial drive resides.

Therefore, we end up with large expensive programs with large cost sharing but without the innovativeness and cost-effectiveness of the real technological might of the U.S. The cost is therefore high for little return. This is only the tip of the iceberg on this issue and a great deal more must be discussed. Perhaps an investigation can be made to diligently assess the truth about this cost-sharing policy. I sincerely believe it will get the mission orientation of the R&D programs.

3. SBIR Program:

The DOE/SBIR program is the hope for this Nation to provide truly innovative technology that is a must for our Nation in energy technology. The program receives a large number of proposals; however, it needs to have authority to spend at least 2% of the SBIR budget on administrative and support activities. It is crucial for the SBIR program to have the tools and support necessary to select the key innovative technologies very carefully. This is key to our future.

Similarly, the Program's budget needs updating for a number of reasons.

- A. Since the Program's inception the funding limits on Phase I and Phase II are \$50,000 and \$500,000, respectively. Therefore, in real dollars, the limit has gotten progressively smaller over the last six years. I recommend that the limit on Phase I should be \$100,000 and Phase II, \$1,500,000.
- B. The limits were set the same, independent of research topics. This is meaningless since some topics inherently require more money than others to do anything meaningful. This is particularly true in certain energy technologies where experimental work even at the laboratory scale is capital intensive. Some people pointed out that with the current funding limits, DOE continues to receive proposals that meet the limits. Nevertheless, that does not prove anything since the inventor who has a great invention knows the limits and if

it is too low to do anything meaningful, he or she cannot in good faith submit a proposal in the first place. The range for Phase II should be made from \$500,000 to even \$2,000,000, based on the topic.

- C. The funding for the SBIR program should be increased to 3% of the agency outlay to allow the program to be meaningful as discussed earlier.
- D. All SBIR contractors must be required to file for U.S. and foreign patents with DOE approval of such filing, including approval of required filing territory. The cost of patent filing must be made an allowable. What is the use of producing new technology to serve the U.S. if the technology is not protected? Are we developing it for Japan and Germany by using our national manpower and tax dollars?
- E. Technology developed under taxpayers' funding cannot be licensed overseas or to a foreign-owned company without a payment by the foreign entity to the U.S. Treasury. This should be the case if the Federal funding was from an SBIR or not. Some review of key technologies deemed to be of strategic national interest must also be made before such licensing is permitted at all.
- F. A MITI-like organization within Commerce must be created that would assist in getting patents issued overseas. Foreign entities are getting patents in the U.S., foreclosing and locking-up our future while we do not seem to get a reciprocal treatment overseas. This is getting very serious and needs immediate attention.

In closing, I note that in the recent crisis we have seen what happens to those that have the technology and those that do not. We also were reminded again regarding our vulnerability due to our energy problems. I am alarmed, however, when I find that energy programs for coal utilization, waste-to-energy conversion, and conservation are essentially abandoned. I am also alarmed that the foreign-owned company capture of Federal R&D funding continues to be on the rise even with tight budgets.

Thank you for your consideration and the opportunity to testify before your distinguished members.

TESTIMONY OF

DR. HILMAR VON SCHONFELDT
EXECUTIVE ASSISTANT TO
THE CHAIRMAN AND CEO
ISLAND CREEK CORPORATION

BEFORE THE

SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

Madam Chairwoman, distinguished members of the subcommittee, I am Dr. Hilmar von Schonfeldt, Executive Assistant to the Chairman and CEO of Island Creek Corporation. Island Creek Corporation is a subsidiary of Occidental Petroleum Corporation. We mine and market approximately 20 million tons of coal annually in our mines in Virginia, West Virginia, and Kentucky. I am providing this testimony to bring to your attention a new and important development in coal combustion technology and to urge you to continue your support to the development and field test of this technology. The program, called "Field Test of a Pulsed Atmospheric Fluidized Bed Combustor (PAFBC)" was initiated through a Cooperative Agreement which was executed between ThermoChem, Inc., the technology supplying participant, and the DOE Morgantown Energy Technology Center in October of 1990.

Utilization of this country's domestic resources should be of the utmost importance to everyone in this country. Coal is the U.S.'s most abundant energy resource and if we are increase coal utilization in the United States it will require innovation and research to accomplish this goal. Pre-combustion coal beneficiation and post-combustion emission cleanup as well as advanced combustion systems that can burn unbeneficiated and reject coal wastes (from beneficiation plants) in an environmentally acceptable manner are technologies that need to be further explored and developed.

Island Creek Corporation has been very active in both areas. We have coal-cleaning and preparation plants at our mining operations in West Virginia, Virginia, and Kentucky and we continue to improve our capability to meet the needs of our clients and the increasingly stringent environmental

requirements. We are also negotiating with ThermoChem to participate in the DOE/METC-funded activity with ThermoChem to investigate the ThermoChem technology application to our needs and its performance in burning unbeneficiated and reject coal streams in an environmentally acceptable manner.

In the following I will first describe to you the technology and its implications to the increased use of coal instead of oil and gas in this country and then I will make a specific request for funding in FY-92. Let me begin with a brief discussion of this new technology.

Bubbling fluid-bed combustion of coal has, for many years, been viewed as a practical method for burning unbeneficiated coal fuels with both sulfur capture and low NO_x emissions. Sulfur is captured by a dry sorbent material comprising the bed, such as limestone or dolomite, and NO_x production is controlled by maintaining a relatively low combustion temperature in the fluid bed. The technology for many years appeared very promising which captured the attention of both equipment manufacturers and end-users. In fact, the technology appeared to offer significant potential for increased coal utilization and hence production and sales for coal-producing companies such as Island Creek Corporation. Nevertheless, this potential and opportunity has not really materialized. The fact is, the atmospheric fluid-bed combustor technology has a serious problem in handling coal fines that are present in crushed coal that is used as fuel. The fines elutriate out of the fluid bed and burn in the freeboard above, forming NO_x , sulfur oxides and carbon monoxide. Many end-users of this technology are forced to screen the coal to

remove fines from the feed and sell or dispose of the fines by some other means. Please note that for many coals, fines content may be as high as 25%. The fines in the coal fed to the fluid bed had to be limited to 7 to 10% of the total coal consumed and the screened fines with their separation and disposal costs compromised the commercial viability and economics of bubbling fluid beds. Today we find but a small number of such units commercially in operation.

In an attempt to resolve these issues, the boiler equipment industry and the development programs moved to pursue the circulating fluid-bed technology. This technology provided the promise of resolving the performance problems but gave rise to large equipment and increased capital cost which put constraints on the commercial deployment of the circulating fluid-bed technology.

The good news, however, is that the DOE/Morgantown Energy Technology Center was well aware of all this and initiated a program in 1987 to address these problems seeking advanced fluid-bed technology for commercial and industrial applications.

One of the technologies that arose from the DOE/METC program was a hybrid combustion system that employs a pulse coal combustor which burns the fines, coupled to a bubbling fluid bed which burns the remainder of the coal. Laboratory-scale test results indicate combustion efficiency of 99.9%+ with low NO_x , very low CO, and extremely high sulfur capture.

ICC is interested in this technology for two reasons. First, this hybrid technology is not sensitive to the presence of large quantities of fines in the coal and, therefore, is potentially (when mature) the technology to replace the conventional bubbling bed combustors that are sensitive to the presence of fines and the circulating fluid-bed technology which comes with prohibitively high capital cost. Secondly, the technology has immediate applications in coal-cleaning preparation plants that produce waste streams of high ash/high sulfur reject coals. These streams include both coarse and fine waste material that can be used on-site by the hybrid pulse/fluid-bed system. The energy produced can be employed in the coal preparation plant operations for drying the beneficiated coal and for other applications. This waste is now being stored in ponds and refuse piles and is not used.

To be specific, DOE has committed \$4,230,534 under the Cooperative Agreement with ThermoChem and others providing for the balance of this technology field test program. The minimum budget required to continue the work in an orderly, cost-effective manner under this Cooperative Agreement is \$3,238,000 in FY-92 funding. The current funding request, unfortunately, does not include any funding for this program which will clearly prevent DOE from being able to meet its obligation under the Cooperative Agreement.

Last year the appropriation process added \$1,200,000 to the President's budget for this program which enabled DOE to commit \$1,181,246 in FY-91 funding to the program. In FY-90 DOE obligated \$251,645 for the first three months of operation under the Cooperative Agreement. Therefore, the total amount to date under the Cooperative Agreement is \$1,432,891. Considering the

initial investment by DOE of approximately \$741,000 in the 1987 - 1988 time frame, the total investment committed to date is approximately \$2,174,000.

In view of the excellent results to date of this modest yet significant investment, I urge the Committee to provide for \$3.238 MM funding of this program in FY-92. This funding will enable the full benefits of this development effort to be achieved. Continuity in such programs is simply essential if we are to be mission-oriented and cost-effective in our quest for energy independence in this country.

In closing, I wish to express my gratitude to the Subcommittee for this opportunity and I hope that you will act favorably on my request.



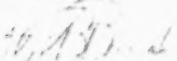
April 1, 1991

Marilyn Lloyd
Chairman
Subcommittee on Energy
Room B-374 Rayburn Building
Washington, DC 20515

Dear Madam Chairman:

Attached is the testimony you requested for the hearing on Fossil Fuels Research and Development, March 5, 1991. We appreciate the opportunity to present the written testimony by Kurt E. Yeager, Senior Vice President, Electric Power Research Institute. If you have any questions, please do not hesitate to call.

Sincerely,



Stephen B. Baruch
Executive Assistant to
Senior Vice President
Technical Operations

9714.SBB.L.cr
Attachment

Written Testimony
by

Kurt E. Yeager
Electric Power Research Institute

to

U. S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Energy

Washington, D.C.

INTRODUCTION

Chairman Lloyd and Members of the Subcommittee: I am Kurt E. Yeager, Senior Vice President for Technical Operations, of the Electric Power Research Institute (EPRI). I appreciate this opportunity to testify on the continued development and use of advanced technology for our nation's, and the world's, dominant fossil fuel resource - coal. This issue is particularly significant because coal technology is one of the most important areas where the United States can act to improve its long term competitive position. The U.S. electric power utility industry, for example, now consumes 80 percent of the one billion tons of coal produced in the U.S. annually to generate 55% of the nation's electricity. It is the primary fuel because of its low cost and wide geographic availability. By 2010, it is likely that coal production will increase to at least 1.5 billion tons per year as total installed generating capacity increases from less than 700,000 MW's to about 900,000 MW's.

EPRI was established by the electric utility industry in 1972 to conduct a broad research and development program for the entire electric utility industry and its ratepayers. EPRI's R&D mission is to develop new and improved technologies for electric power production, delivery and use, and to help accelerate their availability insuring an adequate supply of economic, reliable and environmentally acceptable electricity.

EPRI is supported by voluntary contributions from investor-owned, government-owned and cooperatively-owned electric utilities across the nation. Nearly \$5 billion are being invested by the electric utility industry and EPRI on the development and demonstration of Clean Coal Technology. This commitment is based on the premise that coal utilization and environmental protection are mutually compatible and that improved technology is the key to compatibility. We are particularly pleased that these efforts have become the backbone of the national Clean Coal Technology demonstration joint venture -- bringing the private and public sector together to accelerate the commercial availability of this new technology base for coal.

The United States has historically been the global wellspring for coal utilization technology. As a result, the large majority of coal-fired power plants in the free and developing world have relied on technology sold by, or licensed from, U.S. developers and manufacturers. It is this technical leadership which has sustained the industry's competitiveness in the face of many economic and policy hurdles. This leadership is increasingly challenged, however, by nations which encourage a more cooperative relationship between industry and government coupled with national energy policies which maintain focus on the strategic importance of coal and the technologies for its use. At risk are not only international markets but U.S. competitiveness in our own domestic marketplace.

As the focus of public perception on environment issues moves to the global stage, efficiency improvement to prevent pollution becomes the most practical means to address the interactive, global, core resource issues. Auxiliary emission and effluent controls are eliminated wherever possible, either by avoiding formation of the pollutants or through more efficient process integration with coal-based power production.

A major result of this new attention is recognition that coal-based power plants are rapidly evolving away from the historic boiler-turbine-generator configuration toward integrated resource processing facilities, whether the prime technology is pulverized coal, fluidized combustion, or coal gasification-combined cycle which are now available or gasification-fuel cell technology which could be demonstrated by the end of this decade. The coal gasification based technologies lead to heat rate and emissions control efficiency progress by elimination of the steam cycle. The concept of "electricity without steam" is a technological leap that is within our potential to achieve within the next decade.

The ultimate result can be the transformation of coal-fired power plants from relatively resource inefficient combustion units into fully integrated coal refineries. This can be the basis for the "world class" power plant capable of best addressing the interdependent economic and environmental challenges in our future. Adopting this refining approach to coal utilization for electricity, transport fuel, and chemical feed stocks would be an important element of a technological strategy to concurrently process the total value of our nation's indigenous coal as well as its urban and biological waste resource into an array of products, including electricity.

We are optimistic that coal, which ushered in the electric age 100 years ago, can be poised to meet the challenges of the Twenty-First Century. Whether this goal will be achieved, however, depends on a renewed national commitment to leadership, not just in coal R&D but effective translation of the results into commercial reality on a global scale.

My remarks are intended to put this issue in better perspective and will address the following topics:

- Electricity and Coal
- Advanced Coal Technology
- The Role of the United States
- National Energy Implications

ELECTRICITY AND COAL

First and foremost, it can be confidently predicted that providing for future growth in electricity supply and assuring that electricity is used efficiently will continue to be inseparable from achievement of the nation's economic prosperity in a globally competitive market (Figure 1). During the economic expansion since 1982, electricity growth has paralleled GNP growth while real electricity price has declined 16% and overall energy efficiency has improved 11%. Continued productive improvement in energy efficiency through electrification means that the rate of increase in primary energy consumption is expected to shrink, by 2010, to less than half the annual rate of U.S. GNP growth (1). As these figures indicate, economic progress, energy efficiency and increased electrification have proceeded hand-in-hand, and continued economic growth is expected to raise electricity use to nearly 50% of U.S. energy consumption by the turn of the century (2).

It is also likely that electricity's role in the U.S. (and world) energy economy will continue to grow as dramatically during the next 50 years as it has during the past 50 years. This is based on emerging, environmentally-related, market opportunities where electricity offers unique advantages.

As we enter the Second Electrical Century, this growth business of electricity will continue to depend, as it did in the First, on low-cost energy from coal. Coal use most certainly must be aggressively joined by a nuclear renaissance and promising new resource opportunities essential to a sustainable energy future. Even then, it is likely that coal will continue to produce at least half the nation's electric power through the middle of the next century and, in so doing, act as the bridge to that sustainable future. This forecast is based on the importance of coal as the primary domestic energy source during this period (Figure 2).

Based on examinations of U.S. energy use patterns that consider alternative economic, social, energy availability, environmental, and technological scenarios, we should be preparing for at least a doubling of coal use and an increase in its share of total U.S. energy consumption from today's 26 percent to about 40 percent over the next 50 years (3). Notably, 1990 marked the year in which the U.S. first reaches an annual coal production rate of one billion tons. Thus, the challenge is not whether coal will be used but how to assure its most efficient utilization and resulting lessened impact on the environment. This will be essential to the concept of sustainable global economic and environmental development in the Second Electrical Century.

The importance of the technological linkage between electricity and coal on a global scale is underscored by the Conservation Commission of the World Energy Conference (4) which projects that:

Figure 1

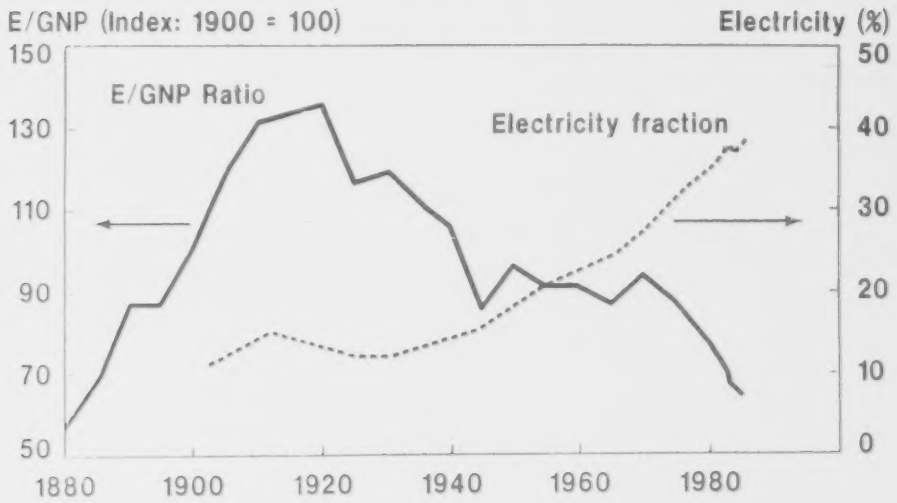
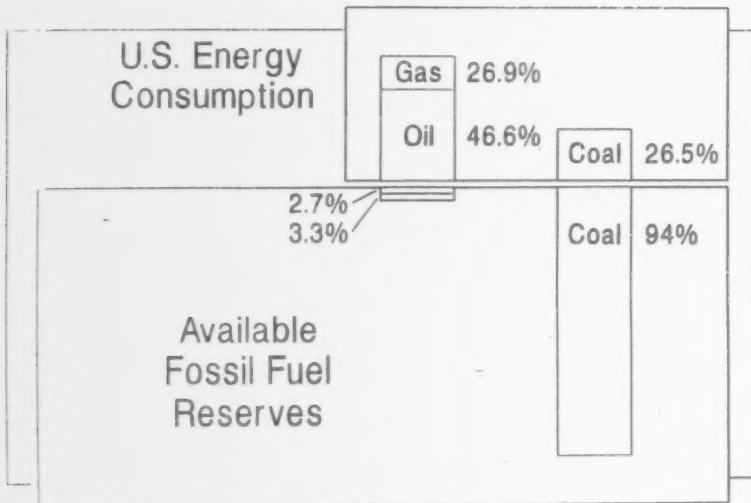
**U.S. ENERGY/GNP RATIO & ELECTRICITY FRACTION
1880-1985**

Figure 2

THE DOMESTIC ENERGY IMBALANCE



Source: U.S. DOE, 1988

- Future global economic growth, particularly in the developing regions, will be associated with very large increases in electricity growth.
- Coal, which provides over 80% of the world's non-renewable energy resource, will become increasingly prominent in the coming decades. Worldwide, coal usage is expected to exceed the use of petroleum during the first decade of the next century and to continue its preeminence during at least the following fifty years.
- Technological innovation to support this expansion in coal use will be essential for the world's environment and its economy.
- The geopolitical importance of coal is also likely to increase since the world's coal resource is predominantly controlled by three nations: the U.S., China, and the USSR. It does not take too much imagination to conceive that the relationship of the latter two with their economically dominant neighbors, Japan and W. Europe, is likely to increasingly be a focus of global energy policy in the coming decades.

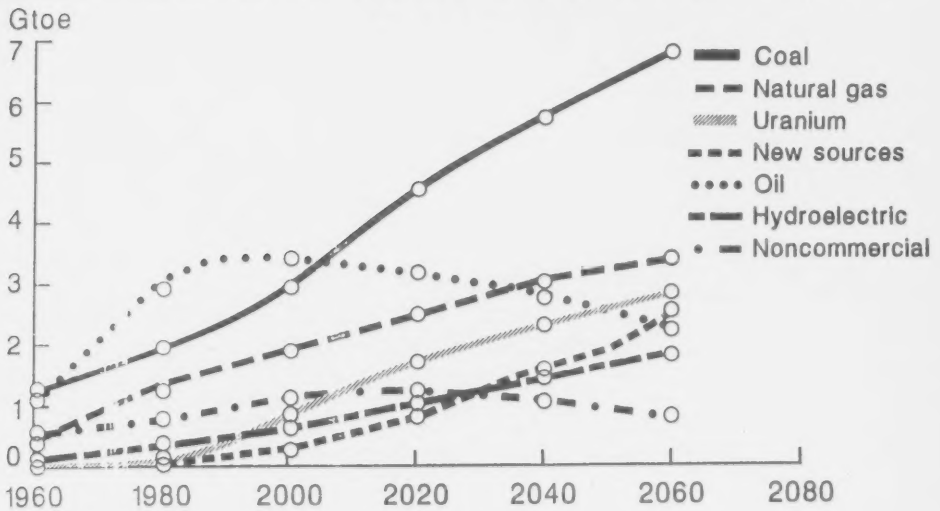
Proven global reserves of fossil fuels other than coal (i.e., resources which can be recovered economically under local conditions using existing technologies) are likely to be consumed by the end of this decade ⁽⁴⁾. That reality will place escalating cost pressure on the use of additional non-coal energy. Escalation is likely to be capped by the cost of producing synthetic fuel from coal and oil shale, assuming our policies encourage that development. This energy consumption versus resource comparison also underscores the need for accelerated, safeguarded, breeder reactor development which could extend the limited uranium resource by a factor of 60. Similarly, the urgency of pursuing renewable energy technology is clear if the developing world in particular is to move beyond what is likely to become an overwhelming dependence on coal after the first half of the 21st century (Figure 3).

ADVANCED COAL TECHNOLOGY

The changes in technology for coal utilization, are being driven primarily by the need to reduce the cost of complying with ever-increasing environmental requirements. As a result, the environmental performance criterion in power plant design is being raised to a level equivalent with the classical engineering criteria of thermal efficiency and reliability, and is being integrated into power generation technology accordingly. Since 1970, the U.S. has increased its use of domestic coal by 90 percent while achieving a 28 percent reduction in sulfur dioxide (SO₂) emissions. SO₂ emissions from electric utilities, which use eight out of every 10 tons of coal consumed domestically, have decreased at a median

Figure 3

EVOLUTION OF WORLD ENERGY UTILIZATION



World Energy Conference - Conservation Commission, 1986

rate of about four percent per year, for an overall reduction of 37 percent. This trend is being extended through the "Clean Coal Technology Initiative". This initiative is bringing a variety of innovative technology options for coal-based power generation into serious commercial consideration after decades of relative technological stagnation (5).

These new options are all intended to provide opportunities to resolve the historic conflicts between coal use and the environment. These conflicts are reflected in the fact that environmental protection costs have typically risen to more than 35% of the investment for a conventionally designed and constructed, coal-fired, power plant (Figure 4).

As a result of these innovative clean coal technology options, the electric power industry stands at a threshold of change in its technological base for coal-fired power generation which can better meet the environmental performance criterion.

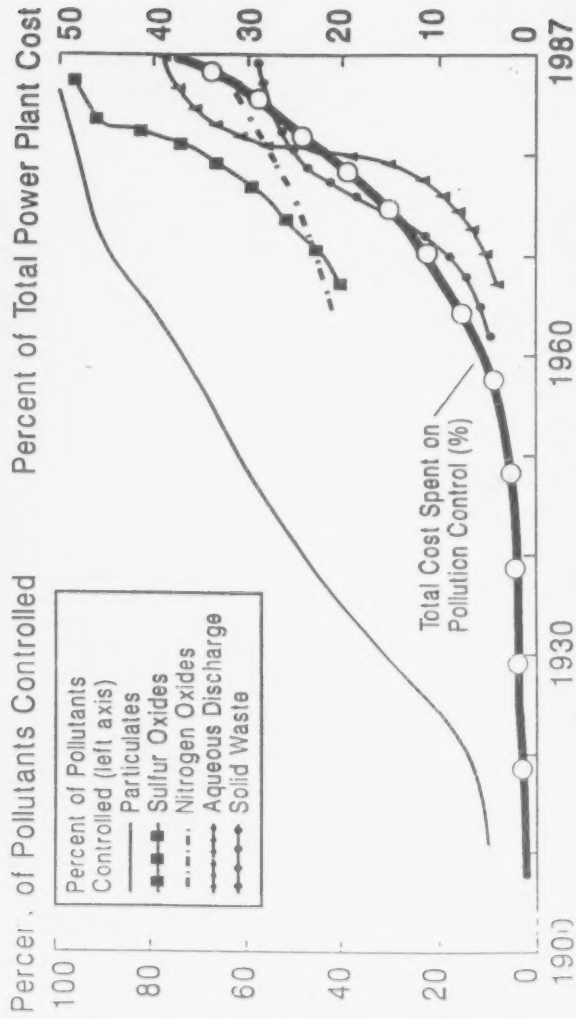
The principle which guides this more innovative clean coal technology development is that sustained environmental improvement can only be achieved when both emission and cost reduction are achieved concurrently, not pitted against each other. The results provide a unique opportunity to concurrently satisfy two national goals: (a) continue the substantial progress made in emission control and (b) meet the rapidly approaching electricity generating capacity challenge with reduced cost and increased productivity.

A major result of this attention is recognition that coal-based power plants are rapidly evolving away from the historic boiler-turbine-generator configuration and toward integrated resource processing facilities, whether the prime technology is pulverized coal, fluidized combustion, or coal gasification-combined cycle.

As the focus of public perception moves to the global stage, and the cost-effectiveness of after-the-fact cleanup becomes increasingly unsupportable, harnessing efficiency improvements to prevent pollution becomes essential as the only practical means to address the interactive, global, core resource issues. This process becomes increasingly urgent under the pressures of economic development, urbanization and population growth. This combination has reached the point where mankind has the capacity to impact the global biosphere. As a result, short-term adaptation to, and longer-term mitigation of, this growing impact is likely to dominate the environmental priorities of the 21st Century. The central policy theme will be how to balance the world's expanding population and economic aspirations against a finite resource base, including the environment. Figure 5 underscores the dramatic relationship between economic development and electrification.

Fortunately, innovative technology through electricity can respond to substantially reduce the amount of energy required to provide a given level of goods and services while simultaneously reducing environmental impact. On

PERCENTAGE OF POWER PLANT COST SPENT ON POLLUTION CONTROL AS PERCENTAGE OF POLLUTANTS CONTROLLED INCREASES



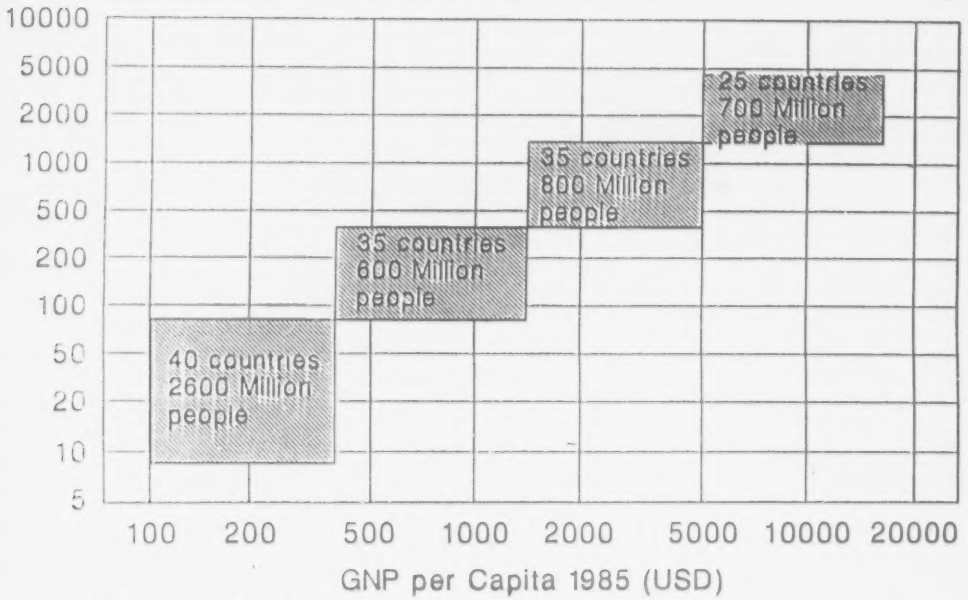
Source: "Coal-fired Power Plants of the Future", Scientific American, Sept., 1987

Figure 4

Figure 5

PROSPERITY AND ELECTRIC ENERGY

Electric Generating Capacity per Capita 1985 (W)



Source: ASEA Brown Boveri

the supply side, adopting a high efficiency refining approach to coal utilization for electricity, transport fuel, and chemical feed stocks would be an important element of such a technological strategy. It would serve to concurrently process the total value of a nation's indigenous coal as well as its urban and biological waste resource into an array of products, including electricity. This would provide the foundation for both continued economic development and environmental protection, including reducing global CO₂ production by one-third over the next 50 years.

Unfortunately the U.S. policy response to environmental risk minimization remains focused on short-range, after-the-fact, "end-of-the-pipe" clean-up expedencies rather than incenting innovative technologies and practices which reduce pollutant formation. The resulting economic impact is large. For example, the U.S. now spends about \$80 billion per year to meet federal environmental control requirements with less than one percent directed to pollution prevention (6). The immediate impact of the 1990 Clean Air Act Amendments will further extend this unproductive situation with no greater emphasis on pollution prevention or efficiency.

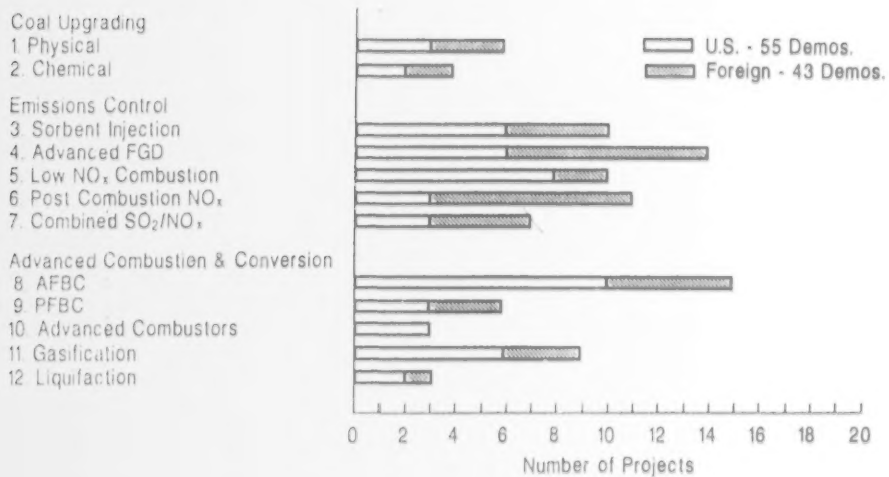
The international nature of the Clean Coal Technology Initiative is reflected in Figure 6 by the nearly 100 demonstrations underway both in the U.S. and overseas (7). This international attention is driven by a growing, world-wide, clean coal technology market valued at about \$80 billion per year by 2000. This market is expected to remain relatively stable in value well into the 21st Century. Table 1 summarizes the basis for this market resulting from the expected global expansion in coal utilization for electric power production.

Table 1
Coal -Fired Generating Capacity Growth

	1990 Installed Coal Capacity (GW)	Expected Coal Growth 1990-2000		Expected Coal Growth 2000-2020	
		%/Yr	New GW	%/Yr	New GW
N. America	340	1.0	30	2.0	180
W. Europe, Japan, Australia	220	2.0	40	1.5	100
E. Europe, USSR	250	1.1	30	1.5	100
China, India, Africa	200	1.3	30	2.0	110
Pacific Rim, S. America	40	7.5	60	4.7	120
TOTAL	1040		190		690

Figure 6

CLEAN COAL DEMONSTRATIONS



Thus, total coal-fired generating capacity world-wide is expected to nearly double over the next 30 years. Essentially all this new capacity will be a candidate for innovative clean coal power generation technology. The U.S. is not likely to play a main role in this market, however, unless our short-term oriented, risk averse national environmental, technology, trade and investment policies are changed to encourage innovative leadership nationally and globally.

THE ROLE OF THE UNITED STATES

The U.S. is best served by focusing on innovative technological opportunities to regain international industrial leadership and competitive advantage. Success will depend on transforming technological advancements -- wherever they may be discovered around the globe -- into high-quality U.S. products, coupled with more strategic trade and investment policies which level the international market playing field, particularly in the developing world.

U.S. international competitiveness is central to our national strategy and influence in the decades ahead. In the future, the traditional approach to foreign policy will have to give more serious consideration to strategic industrial issues, such as the strength of the U.S. manufacturing base and the leverage of key technologies across industries. This shift in focus will require a reassessment of both the priorities that govern foreign policy and the government institutions that are involved in the policy making process. National security can no longer be viewed exclusively in military terms; economic security must be taken into account. This will necessarily have an impact on the management of international relations, since important political allies are often hard-nosed economic competitors in commercial technology ⁽⁸⁾.

It has been fashionable to consider U.S. manufacturing as synonymous with moribund industries that had more to do with America's industrial past than its high-tech future. It is now becoming recognized again that a strong manufacturing base is essential to leading-edge industries as well as to mature industries, and that technological and commercial "food chains" connect so-called low-tech and high-technology industries. Moreover, mastery of the manufacturing process is increasingly viewed as an essential part of the technical competence that is necessary to advance existing technologies and create new ones.

Fortunately, the U.S. still remains a technological and commercial leader for the higher value-added gas turbine, fuel cell, coal conversion, and silicon micro-processor technologies, all essential to a least cost, refining approach to power production and a coal-based national energy economy. These technologies provide incentives for U.S. corporate innovative and commercial leadership because their advantages in the global marketplace have, so far, been sufficient to offset the deficiencies of U.S. trade, tax and commercial collaboration policies. For example, leadership in gas turbine and other post-Rankine steam cycle energy

conversion technology, such as fuel cells, reflects U.S. leadership in defense and aeronautics technology. Coal conversion technology results from strategic R&D investments by the petroleum and chemical industries which control the bulk of U.S. coal resources and are culturally and technically familiar with a chemical processing approach to resource utilization. Finally, microprocessor technology is a powerful and rapidly expanding result of the \$400 billion per year, U.S. electronic industry, where 20% of all U.S. industrial research is conducted.

Paradoxically, it is these three relatively robust technological foundations, not now dependent on the power or coal industries, that will become increasingly important to U.S. coal and power generation, assuring both their competitive future and that of the nation to whose prosperity they are so closely tied. When combined, they provide the means to break the steam cycle efficiency barrier for coal-based electric power production with an impact similar to that of jet aircraft on the sound barrier and air travel 40 years ago. The ultimate result can be the transformation of coal-fired power plants from relatively resource inefficient, combustion units into fully integrated coal refineries. This can be the basis for the "world class" power plant capable of best addressing the interdependent economic and environmental challenges pacing the 21st Century. The U.S. is poised through its combination of technology and coal resources to provide world leadership for this transformation. The payoff is not just commercial advantage but resource conservation and environmental protection on a global scale.

Invention will not be enough, however. Sustained competitiveness through innovation also will require a better linkage of government and private R&D funding to the productivity of commercial products; strengthening the manufacturing base; the establishment of, and commitment to, higher technical quality standards; investment in the technological training of workers, and a better basic education for all citizens (9). Policies will have to be altered to encourage sustained, long-term investment in improved skills and facilities necessary to advance the creation and use of technology. This is necessary to encourage long-term global market development and to promote innovative commercial leadership, increasingly dependent on collaborative R&D.

The current environment of increased international corporate flexibility in the quest for economic advantage encourages these collaborative, national, enterprises that focus public and private resources and risk-sharing for advantage in attracting and building the corporate economic base. This strategy of establishing national "arsenals of innovation," is already being exploited successfully by other nations. Their importance to the U.S. may be as much in building the new relationships among businesses, universities and the government necessary to compete internationally, as in actually creating technological innovations (8). Underpinning all of these steps is the need for a greater sense of personal responsibility for the future and a more cooperative, less adversarial, approach by both the public and private sectors to marshalling our unmatched national capabilities.

An important driving factor is underscored by the February 1991 National Energy Strategy⁽¹⁰⁾. This strategy, unless changed to emphasize domestic resources, is projected to result in the importation of 40 percent more oil by 2030 than today with a corresponding negative impact on the nation's foreign trade balance and an untenable threat to national competitiveness and security (Figure 7). Under these conditions, domestic oil replacement resources based on coal-derived synthetic fuels, can phase down oil imports, and ease the transition from direct internal combustion powered vehicles to electrified urban personal and public transportation.

This conversion to domestic resources is encouraged by the linkage among trends which appear likely to reach their climax as we enter the new century. First, the probability that oil prices will rise rapidly as demand exceeds proven reserves and Middle East "preferred" production capacity is exceeded, even under politically stable regional conditions. Second, political pressure in the urban centers of the U.S., Europe, and Japan to phase out internal combustion-powered vehicles. Third, the escalating negative impact of imported oil dependence on economic competitiveness and the resulting untenable political stresses created among the U.S., Europe, and Japan.

The coincidence of such climactic trends, all driven by scarce resources, has historically forced economic crises triggering rapid political reaction. Fortunately, among the three major Western economic blocks, the U.S. has the advantage in being able to phase out its imported oil dependence in favor of indigenous resources. This is likely to be an exceptionally important international business advantage while protecting political cooperation from the stress of competition for dwindling resources. As a result, U.S. coal may prove to be as important to protecting the Western alliance during the next 50 years as the U.S. military umbrella has been during the past 50 years.

~This goal is most likely to be achieved through integrated processing facilities capable of translating coal and other carbonaceous material into a variety of products including, but not limited to, electricity (Figure 8). Power production from these facilities will be one product of a broader resource processing capability that can also competitively produce transport fuel and chemical feedstocks, and recover marketable mineral credits⁽¹¹⁾. The economic importance of such a co-production approach is underscored by its potential to reduce electricity generating costs by 25% or more (Figure 9). Controlling the commercial high ground in this coal-based energy revolution will likely be one of the most important economic determinants facing the coal and power industries, and this nation, over the next 20 years.

Figure 7

OIL CONSUMPTION & PRODUCTION National Energy Strategy

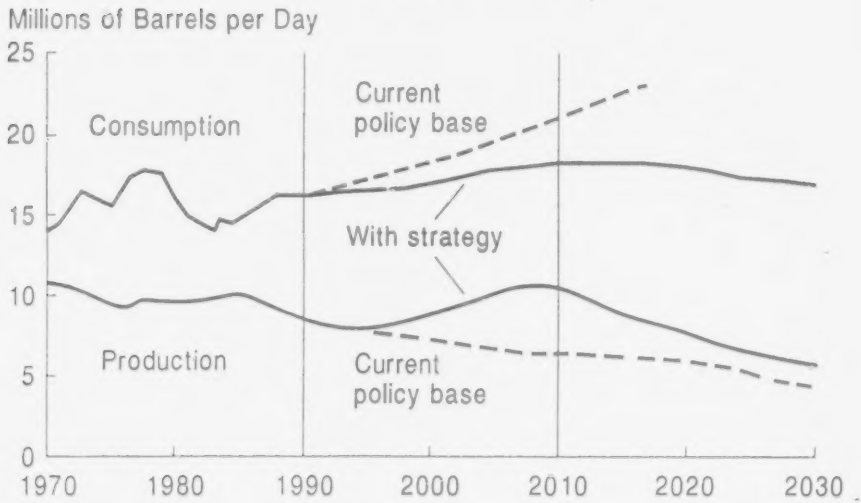


Figure 8

INTEGRATED COAL REFINERY CONCEPT

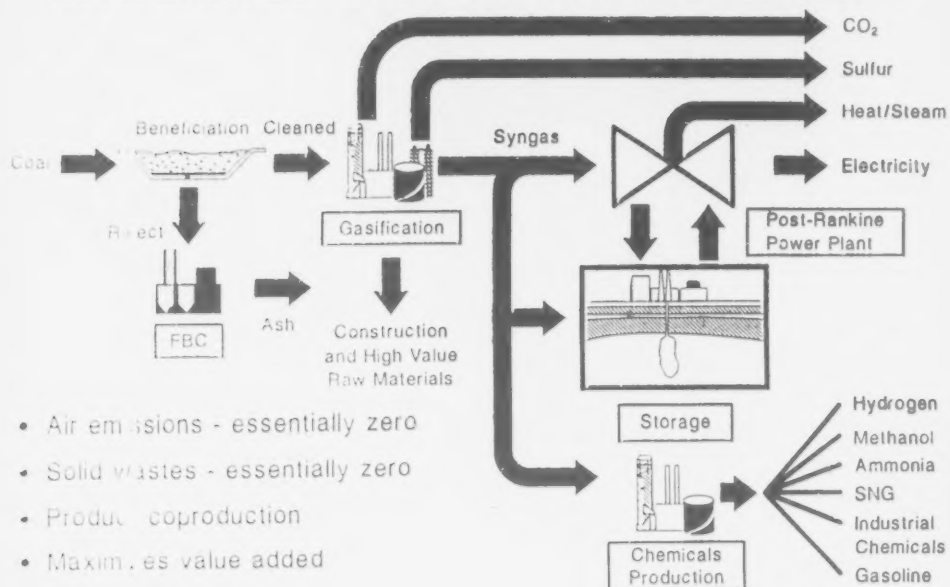
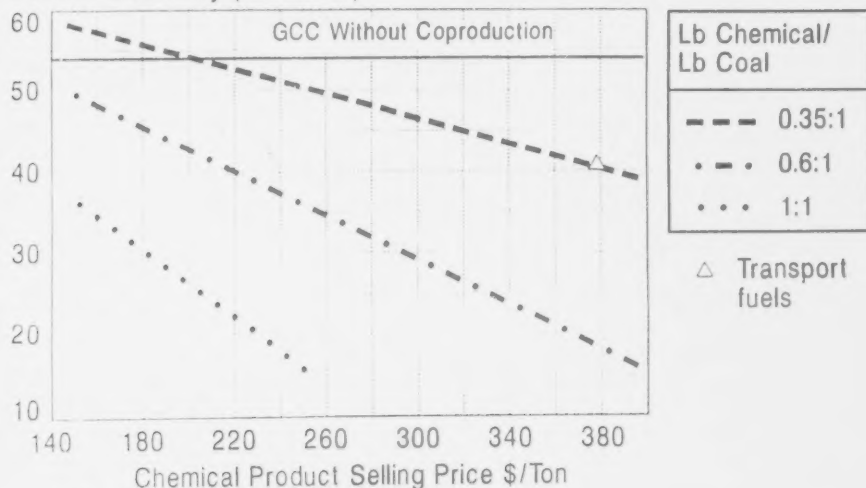


Figure 9

COST OF ELECTRICITY VS. \$/TON Chemical Byproducts From A 400 MW GCC

Cost of Electricity (Mills/kWh)



Note: Cost of coal = \$1.62/MMBtu

The state-of-the-art in this coal refining technology is reflected by the commitment of the SEP electric utility in the Netherlands to build a 2000 ton/day, coal gasification combined cycle power plant generating 250MW of electricity for startup in 1993. Similar projects are also under consideration for the 1990s here in the U.S., if public perceptions and policies do not contradict their timely implementation (Figure 10).

Coal gasification will be the core technology for this transitional strategy, which will lead to clean, high efficiency, coal fired plants. Advanced devices, such as high temperature gas turbines and molten carbonate fuel cells, convert the chemical energy in fuels to electricity more efficiently than boilers. They do, however, require clean fuels for effective operation. Since coal gasification creates a fuel gas which can be cleansed of pollutants without the formation of waste products, it can be coupled with the very efficient energy conversion devices noted above (12). It is thus possible to reduce the amount of coal required to produce a unit of electricity, relative to a coal fired boiler with back end emission controls (scrubbers and selective catalytic reactors), by 1/6 with Integrated Gasification Combined Cycle technology and by 1/3 with Integrated Gasification Molten Carbonate Fuel Cell technology (Figure 11).

In short, the result of this technological transformation will be an integrated energy and resource production foundation based on indigenous fuel which can serve not only as a transition energy capability for the U.S. and other developed nations but a fundamental economic base for the less-developed world as well. The mortar that cements, or integrates, these coal utilization building blocks and makes them an operationally practical reality is the same microprocessor revolution which is now being technically and culturally assimilated to enhance the productivity of existing power plants. This "smart" instrumentation would enable knowledge-based diagnostic and control systems to manage plant operations as well as robotic systems to perform maintenance and inspection.

The national goals for this progress require little vision. They are:

- providing at least 200 GW of new electrical generating capacity;
- replacing 10 million barrels per day (MBD) of oil imports.

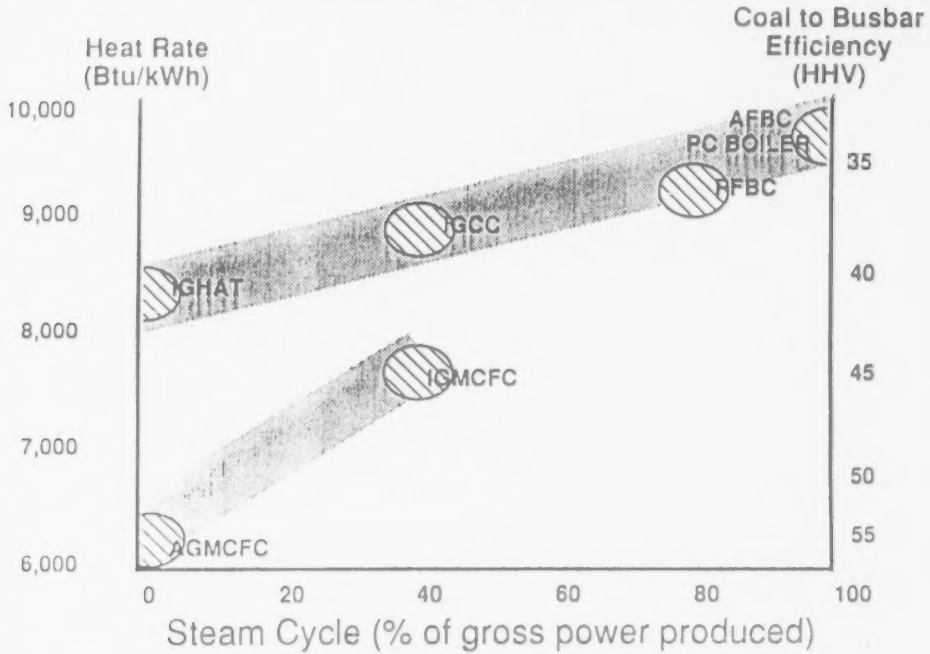
Achievement of these goals by 2010 is not simply desirable but appears essential to our national economy, security and environment.

The policy steps needed to accomplish these goals are incentives to (a) immediately phase down oil imports in favor of domestic sources, and (b) reduce pollutant formation through the harnessing of real technological innovation to domestic energy production.

Figure 11

Coal Fired Power Cycles

Heat Rate vs. Steam Cycle Contribution

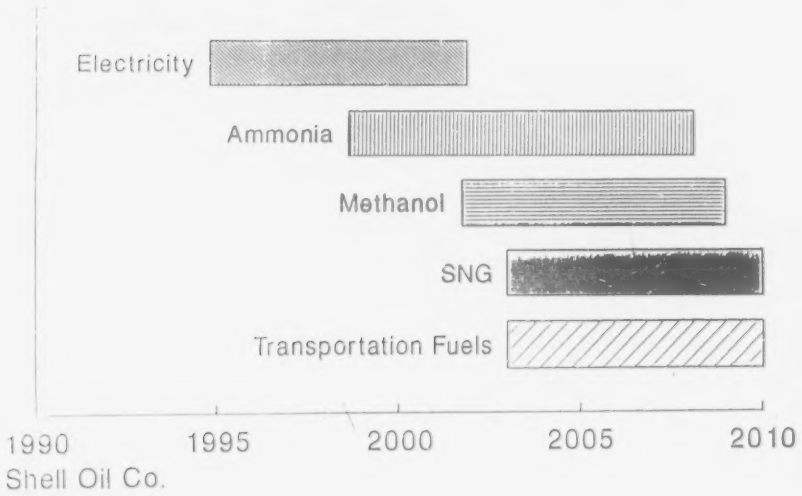


Legend

PC	Conventional pulverized coal boilers with flue gas desulfurization
AFBC	Atmospheric fluidized bed combustion
PFBC	Pressurized fluidized bed combustion
IGCC	Integrated gasification combined cycle
IGHAT	Integrated gasification humid air turbine
IGMFCF	Integrated gasification molten carbonate fuel cell
AGMCFC	Advanced gasification molten carbonate fuel cell

Figure 10

TIMING FOR EARLIEST U.S. COMMERCIAL APPLICATIONS OF COAL GASIFICATION



The direct commercial benefits to the nation through lower cost electricity, increased power equipment exports, and reduced oil imports alone are expected to escalate, over the next 20 years, to at least \$150 billion per year or six times the required \$25 billion per year investment. To this should be added the broad fabric of economic benefits resulting from a more competitive economic posture in the world market. Within the required investment, less than one percent would be necessary to complete development of the already well-defined technology base.

As attractive as this opportunity seems, its initial payback period is simply too long and too subject to political manipulation to attract investment under current short-term profit oriented, risk-averse, national policies. As pointed out repeatedly through this paper, these policies, and the perceptions on which they are based, must be changed if this inevitable technological transition is to occur with the greatest commercial and environmental benefit to this nation.

We have unparalleled means to continue to prosper as a nation while being the global leader in productive resource stewardship. The issue remaining is whether, also as a nation, we have the patience and proactive will to invest in this sustainable future or simply continue short-sighted expediencies. The bottom line is whether we care enough to guide our own destiny or leave it to others by default.

NATIONAL ENERGY IMPLICATIONS

Fundamental to addressing the energy challenge is a more proactive American response to global competition among what are now relatively equal economic competitors. In evaluating this pre-eminent national issue, the conclusion is the same as Pogo's - "we have met the enemy and he is us". The greatest threat to our competitive position is not foreign but our own national preoccupation with short-term, risk-averse, policies relative to our more strategic and globally oriented competition. This attitude, encouraged by the perception that post-war U.S. global economic advantage could be taken for granted, is a luxury which the U.S. can no longer afford if we are to sustain national economic and ecological prosperity into the next century.

This transformation will depend on three factors: First, recognition that the unprecedented advances in health, safety and longevity have been the result of the wealth created by our society's entrepreneurial system and its ability to capitalize on technological innovation. History shows that our current preoccupation with no trial without prior guarantee against error is a sure prescription for national voyage into harm's way, both environmentally and economically. The second factor is a change in public perception to one that mandates the same sustained commitment to the unmatched U.S. "soft" power advantage in resources and technology that has marked our military leadership

over the past 50 years. Third, this commitment must be reinforced by public policies recognizing that national economic and environmental security are as dependent on industrial technology as military strength.

This may prove to be a crucial test of the U.S. Constitutional system's ability to produce sustained and coordinated action dealing with long-term problems in a global society where urbanization and economic differentiation are increasing. If we are successful, however, this transformation can be both the foundation for rebuilding America, and the arsenal of electricity-based energy innovation powering the new century.

This requirement seems particularly germane to the inter-connected agenda driving the Secretary of Energy's National Energy Strategy initiative. This agenda focuses on: electricity reserve margins, environmental pressures on coal, the future of nuclear power and oil imports. The strategic element linking these agenda items is electricity and the technology for its global development. Official U.S. energy policy, however, has historically remained a political creature reflecting popular perceptions of the moment. It has been made up of numerous narrow policies intended to stimulate specific actions for explicit goals, usually established in differing times and circumstances. Thus, it is not surprising that these independent policies are often in conflict and unable to maintain a progressive balance among the numerous competing interests. Achieving such a balance would require a 30-year or longer perspective and, to date, a politically unrewarding concern for the energy structure available to future generations. For example, only immediately after the oil supply interruptions of 1973 and 1978 was there sufficient, but temporary, popular perception of the precarious nature of our dependence on foreign fuel sources to encourage even a fleeting policy glimpse of oil supply reality.

The one enduring factor overlying U.S. energy policy has been the pressure to eliminate environmental side-effects and risks associated with energy systems. Unfortunately, against the false perception of unconstrained energy security and unaffected economic competitiveness, the policy response to environmental risk minimization has focused on short-range clean-up expediencies. This is contrary to achieving a sustainable national, let alone global, balance between energy use and the environment which depends on preventing pollutant formation. The result has been ever larger energy and environmental stresses plus diminished economic competitiveness.

It is therefore disappointing that the National Energy Strategy's appropriately aggressive proposals to reestablish nuclear power are not matched by an equally aggressive vision for our other domestic energy sources, particularly coal. The result, as indelibly outlined by that same strategy, will be increased oil imports, relatively inefficient use of our primary energy resources, coal, and little progress toward a post-carbon energy economy necessary for a sustainable global energy future.

The more we study the major energy problems of our time, the more we come to realize that they cannot be understood, let alone solved, in isolation. They are systemic problems - interconnected and interdependent; and their solution suffers from a "crisis of perception" reinforced by short range policy expediencies. Science has shown that a holistic view - seeing the world as an integrated system rather than separate parts - is essential if we are to sustain progress in environmental protection while developing the resources needed for global economic development. Technology, in turn, is providing the means to achieve that sustainable future if we, in turn, sustain our commitment to innovation.

CONCLUSIONS

1. Innovative Clean Coal Technology provides the means to resolve the conflicts between coal use and the environment while protecting U.S. competitiveness in the global marketplace. This is particularly important because of the probability that coal will surpass petroleum as the world's primary energy source by early in the 21st century.
2. The U.S. is not likely to play a major role in this \$80 billion per year technology market unless our short-term oriented, risk-averse national investment, trade, technology and environmental policies are changed to encourage a national arsenal of energy innovation. Success will depend on (a) transforming technological advancements - wherever they may be discovered around the world - into high-quality U.S. products and (b) trade policies which reinforce U.S. competitiveness by encouraging strategic investment opportunities.
3. Sustained competitiveness through innovation will require a better linkage of government and private R&D to the productivity of commercial products; strengthening the manufacturing base; the establishment of, and commitment to, higher technical quality standards; investment in the technological training of workers; and better education for all citizens. Policies will have to be altered to encourage sustained, long-term investment in improved skills and facilities necessary to advance the creation, production and use of technology.
4. These national energy related policies should encourage a sustainable balance between energy use, economic competitiveness, and the environment. This will require a change in public perception to one that mandates the same sustained national commitment to creating U.S. "soft power" advantages in coal and technology similar to the unmatched accomplishments that have marked our military power leadership over the past 50 years. National security can no longer be viewed exclusively in military terms.

5. The U.S. has the unique advantage in being able to phase out its imported oil dependence in favor of indigenous resources. This is likely to be an exceptionally important international business advantage while protecting political cooperation from the stress of competition for dwindling resources. As a result, U.S. coal may prove to be as important to protecting the Western Alliance during the next 50 years as the U.S. military umbrella has been during the past 50 years.
6. To be successful, energy policies must instill an appreciation among all sectors of the society that a more strategic use of our limited natural and capital resources is imperative if we are to retain global economic leadership. If political impatience on environmental issues is allowed to continue to dominate the policy process, we will waste enormous resources and commercial opportunities while actually increasing environmental risk. Our choice is clear: continue to focus on "retro" cleanup, which moves the environmental impact around while reducing national productivity, or encourage innovative technology, which eliminates pollutant formation and improves national productivity.
7. As the focus of public perception moves to the global stage, and after-the-fact cleanup becomes increasingly unsupportable, harnessing energy efficiency improvement to prevent pollution becomes essential as the only practical means to address the interactive, global, core resource issues. The central policy theme will be how to balance the world's expanding population and resource aspirations against a finite resource base, including the environment.
8. A refining approach to coal utilization based on coal gasification to produce a variety of products, including at least 50 percent higher efficiency electricity, provides both much higher energy productivity as well as enhanced energy security and global competitiveness. This will be the basis for the world class fossil power plant capable of best addressing the interdependent economic and environmental challenges of a sustainable energy future. It is the essential technological building block for an energy strategy addressing the realities of the coming decades.
9. Fortunately, the U.S. remains a technological and commercial leader for the gas-turbine, fuel cell, coal conversion, and silicon microprocessor technologies essential to this least cost refinery approach to power production and a coal-based national energy economy. The issue remaining is not technological but the national patience and focused, proactive, will to encourage this domestically sustainable energy future.

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**FUEL CELL ASSOCIATION**

Suite 403
1627 K Street, NW
Washington, DC 20006
(301) 681-3532

April 5, 1991

The Honorable Marilyn Lloyd
Chairwoman
Subcommittee on Energy
U.S. House of Representatives
Room B-374 Rayburn House Office Building
Washington, D.C. 20515

Dear Madam Chairwoman:

The Fuel Cell Association (FCA) was unable to testify before the Subcommittee on Energy, House Committee on Science, Space and Technology, regarding the Administration's proposed National Energy Strategy and the U.S. Department of Energy's Fiscal Year 1992 budget for fuel cell R&D (the latter is contained within both the Department's fossil energy and conservation programs.) Consequently, we wish, instead, to submit our prepared statement for the records of the Subcommittee. I enclose 50 copies of our statement for distribution within the Subcommittee.

The Fuel Cell Association comprises about 60 corporate and associate members, including companies that develop, design, and use fuel cell systems and components. Our Association is the only organization in this country representing industry in its desire to achieve the earliest commercialization of this technology.

Should you need further information, please contact me at (Area Code 517) 636-0411 or our Executive Director, Mr. Martin Gutstein, at the Association's phone number given above.

Thank you for the opportunity to submit our testimony for your records.

Sincerely,

A handwritten signature in dark ink, appearing to read 'J. Gunsher'.

Jeffrey A. Gunsher, Ph.D.
President

STATEMENT OF
THE FUEL CELL ASSOCIATION
For the record of the
SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
--April 5, 1991--

I. Introduction

Billions of dollars and the lives of precious soldiers have been spent in defense of the principle that one country, Iraq, cannot occupy and pillage another. One of the reasons that led Saddam Hussein to move into Kuwait in August, 1990 was to gain control of a major share of the world's supply of oil—the supply located in the Middle East. The impetus for Saddam's invasion was the fact that oil remained in great demand throughout the world.

During the 1980s, the U.S., Europe, and the other oil-consuming nations of the world neglected to reduce their dependency on this fuel. In the U.S., we relied on market forces to set energy policy. We counted on an orderly marketplace, one that would not incur major instabilities from the Mideast or elsewhere. I don't have to remind the members of the Energy Subcommittee what happened to energy R&D funding during the 1980s as a consequence of this dependence on the market. The result was the U.S. implemented what can be called an "under-policy," that is, we underfunded research, underfunded development, and underfunded demonstrations of new energy technologies, technologies superior to those in use today. Thus, the U.S. lost an entire decade during which more efficient and environmentally sound energy conversion and fuels-producing technologies could have been commercially introduced and which would have positioned this country to have begun, during the nineties, a significant reduction in the use of petroleum.

During the decade of the 1980s, many individuals and energy organizations, including the Fuel Cell Association, warned of this energy R&D "under-policy" to no avail. As a consequence of the events in the Gulf, the U.S. can no longer delay, bury its head in the sand, or depend on stable oil markets--we've learned our lesson the expensive way. We must now strive to fashion a true energy policy, one that includes strong support for R&D, to meet the needs of the country and the new "world order."

II. FCA's Recommended National Energy Goals

FCA recommends that the U.S.' energy policy focus on the following national goals:

GOAL NO. 1: Reduce the U.S.' dependence on oil, especially, imported oil

GOAL NO. 2: Protect the environment

GOAL NO. 3: Assure an adequate supply of fuels and power in all sectors of the economy, but especially, transportation, the sector most dependent on petroleum

FCA strongly urges a balanced Research, Development & Demonstration (R,D&D) program as one of the keystones of the new energy policy to help this nation achieve the goals just delineated. By a balanced R,D&D program, we mean one that encourages:

- Both production and conservation
- Reasonable levels of assured, long-term support for R,D&D in nuclear, fossil and renewable energy, in addition to energy conservation
- Support for all phases of energy R&D, including basic and applied research, development, and demonstration, with increasing levels of cost-sharing as the technology approaches the marketplace. The Federal government should also provide limited, cost-shared support for information dissemination for new technologies to help speed commercialization, where the industries are too new or too weak to do the job themselves
- Cooperation among industry, the Department of Energy, and the Environmental Protection Agency to define and solve environmental

problems that might arise from new energy technologies well before these technologies enter the marketplace

III. The Role of Fuel Cells in the Nation's Energy Policy

We believe that fuel cells provide the U.S. with an extraordinary opportunity to contribute to the successful achievement all three national goals. For example:

- Fuel cells can convert the energy of fuels, including petroleum-based fuels, to electricity at very high efficiencies (in some cases, almost twice the efficiencies of current conversion systems). Fuel cells will therefore produce more electricity per gallon or cubic foot of fuel than almost any other system. This translates into less consumption (i.e., increased conservation) of fuel and less dependency.

- Fuel cells can produce electricity from a variety of fuels, including natural gas, methanol, coal-derived fuels, hydrogen, and ethanol, land-fill gases, and other biofuels. Thus, users have many options with regard to alternative fuels they might want to employ in order to reduce their dependence on oil.

- Fuel cells are environmentally benign. They produce primarily carbon dioxide (CO_2) and water. (Although CO_2 is a "greenhouse" gas, the high efficiencies of fuel cells means much less is produced per kilowatt-hour of electricity generated.) Oxides of sulfur and nitrogen emitted by fuel cells are a factor of ten less than current EPA regulations. Fuel cells are so clean, they can be installed in the heart of cities.

- Fuel cells can play a major role in almost all energy applications: Only the imagination limits the use of fuel cell systems. For example, plans are already underway in this country to manufacture, albeit on a limited basis, phosphoric acid fuel cells (PAFCs) of 200-kW to 1-MW capacities. These systems will be used by gas utilities to serve commercial and light industrial customers. A demonstration of one U.S. company's PAFC fuel cell technology is proceeding in Japan for large, multi-megawatt electric utility power plants and another company's PAFC will see service at a chemical plant in Europe. Two consortia of North American electric utilities are supporting the development and demonstration of multi-megawatt molten carbonate systems.

The Allison Division of General Motors and the U.S. Dept. of Energy are working together to develop a fuel cell system that could provide competitive power in **transportation applications**. This concept employs a "proton-exchange membrane" fuel cell which has the potential to supplant the internal combustion engine. As such, it would use much less fuel and would be substantially cleaner. Another project, jointly sponsored by DOE and the Dept. of Transportation, is exploring the integration of a phosphoric acid fuel cell system and batteries to drive an **urban bus**. Both vehicular fuel cells would operate on methanol which can be made from natural gas, coal, and biomass, as well as from petroleum stocks.

Fuel cells are being developed to drive ships and submarines and they could be developed for trains and trucks. Fuel cells can be coupled with solar energy systems to provide clean, efficient round-the-clock electric power generation. In the future, they can be used to provide both electricity and heat for **residences**.

Fuel cells can even find use on the farm: A recent study by EA Mueller, Inc. of Baltimore, MD of fuel cells for use in **greenhouses** suggest that significant increases in production can be achieved with fuel cells when: the electric output is used to extend the illumination of the growing plants; the system's "waste heat" is used to warm the hothouses; and the output carbon dioxide is used to encourage photosynthesis. Fuel cells operating in this mode are truly "total energy" systems-almost nothing is wasted.

• **Fuel cells are cost-effective.** For example, fuel cell developers have estimated that the cost of molten carbonate systems in large-scale production may be less than \$1,000 per kW (plant installed cost, 1989 \$), directly competitive with other power generation equipment at the same capacity level.

It should be clear from this overview that the full potential of fuel cells has not been exploited by this country. **We need to get on with the job!**

IV. Fuel Cell Program to Meet National Goals

What additional R,D&D and other assistance is needed to fully exploit the high energy efficiencies and minimal environmental impacts of fuel cells? FCA offers the following four recommendations:

1. **Catalyze and provide financial support for the tests of demonstrations and commercially-ready systems in order to help bring fuel cells into the marketplace.** Each plant would be constructed and operated by a separate team or partnership comprising vendors, users, state and local governments, and the Federal government. Each participant in the team would help pay the costs and, hence, help share the risks.
2. **Increase the participation of industry and universities in fuel cell research and development in order to achieve the best performing, lowest cost systems.**
3. **Increase R&D for innovative fuel cell concepts for transportation, stationary power, residential, and industrial applications and for integration with renewable energy and biofuels processes.** (This recommendation requires new starts in elements of DOE's Conservation and Renewable Energy program. In the past, the DOE managers of the industrial, solar, biofuels, and buildings programs have resisted supporting fuel cell applications primarily because they felt the lack of a clear charter. We ask Congress to authorize the Conservation and Renewable program to include in all their areas of responsibility, not just in transportation conservation alone, the development and testing of fuel cells as a legitimate and necessary part of their mission.)
4. **Provide Cost-Shared Support for an Information Dissemination program with industry.** Very few companies in the U.S. that can use fuel cells, other than electric and gas utilities, and very few investors, financiers, and local and state regulators are knowledgeable about this technology and its benefits. The commercialization of fuel cells is limited, to an important extent, by this lack of information.
5. **Per the proposal of the late Senator Matsunaga, assign fuel cells to the category of a renewable energy system.** This will enable our industry to participate in, and benefit from the

activities of the DOE/AID/Dept. of Commerce Committee on Renewable Energy Commerce and Trade (CORECT), thereby promoting exports of fuel cell systems..

The Fuel Cell Association would be pleased to meet with members of the staff of this Subcommittee in order to discuss these specific recommendations in detail. We urge the members of the Subcommittee to work towards implementing our recommendations in order to help speed the commercialization of fuel cells.

V. DOE FY1992 Budget

FCA presents its suggestions and rationale for the DOE fuel cell R&D budgets for FY1992 in the paragraphs given below. It should be understood that the budget recommended below reflects FCA's view of the current DOE program; it does not include funds for the efforts proposed above.

FCA'S RECOMMENDATIONS FOR DOE'S FY1992 BUDGETS

I. Fossil Energy

A. Phosphoric Acid Technology \$4.0 Million

Phosphoric acid fuel cells (PAFCs), the most mature fuel cell technology, are on the verge of entering the marketplace. Funding of \$4 million is recommended to provide the third and last increment for testing air-cooled modules. Successful completion of this project will help bring this PAFC to the next phase of development, that is, a demonstration plant. Plans already exist for the private sector to fund such a plant.

B. Molten Carbonate \$43 Million

FCA strongly urges support for development of this most attractive fuel cell technology. In particular, we urge funding of \$24 million to continue the two cost-shared system/stack contracts selected under the FY90 competitive solicitation and \$4 million to continue stack research with the third developer. FCA recommends the sum of \$3 million for support of molten carbonate base technology activities both in industry and DOE laboratories. The Association urges full funding of \$12 million to initiate the industry-government cooperative program,

solicited in Fiscal Year 1991, aimed at demonstrating pre-commercial MCFC stacks in order to help accelerate the market entry of of this fuel cell system concept.

- C Advanced Concepts: Solid Oxide \$20 Million

FCA recommends allocating \$15 million to continue cost-shared technology development on tubular Solid Oxide Fuel Cells and \$5 million for technology for other advanced concepts, including the monolithic concept.

- D Advanced Research \$4 Million
 Technology Development

This level of support will provide the opportunity to perform generic applied research in basic electrochemical science and to investigate new, low-cost concepts in the private sector to improve fuel cell system performance.

Total for Fossil Energy: \$71 Million

II. Transportation Conservation

- A. Fuel Cell-Battery
 Bus Program \$3.5 million

Cost-shared funding of \$3.5 million is recommended in order to continue the effort to integrate a full-size phosphoric acid fuel cell/battery propulsion system into a testbed bus and to demonstrate proof-of-concept.

- B. Proton Exchange Membrane (PEM)
 Development Program \$8.5 million

DOE has initiated a cost-shared Proton Exchange Membrane (PEM) fuel cell technology program with the Allison Division of General Motors Corp. for transportation applications. Under Phase I, the program will demonstrate a 5 kW "breadboard" system and conduct R&D leading to a fast-response reformer. Funding of \$8.5 million is recommended to continue this important effort.

C. Applied Fuel Cell Research \$5.0 million

FCA recommends that funds be provided to support activities such as: PEM fuel cell applied research, including improved membranes, water management, integration of thermal management system, reducing carbon monoxide poisoning, etc.; feasibility of Monolithic Solid Oxide Fuel Cell (MSOFC) technology for transportation applications; direct oxidation of methanol; and joint industry/government projects aimed at understanding basic fuel cell phenomena, including corrosion, reformer design, etc.

D. Advanced Systems \$2.0 million

Initiate an evaluation of the feasibility of integrating fuel cell technologies in locomotives and other heavy-duty transportation applications.

Total for Transportation Conservation:	\$19.0 million
--	----------------

TOTAL FY 1992 DOE FUEL CELL PROGRAM RECOMMENDED BY FCA:	\$90.0 million
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VI. Concluding Remarks

FCA appreciates the opportunity provided by the Subcommittee to present its viewpoint for the record on the efforts and funding needed to bring clean, efficient fuel cell power generation technology to commercial reality.



American Chemical Society

OFFICE OF THE PRESIDENT

S. Allen Heninger
President-Elect, 1990
President, 1991
Immediate Past President, 1992

1155 SIXTEENTH STREET, N.W.
WASHINGTON, D.C. 20036
Phone (202) 872-4600
April 22, 1991

The Honorable Marilyn Lloyd
Chairman
Subcommittee on Energy
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Madam Chairman:

The American Chemical Society has reviewed with keen interest the U.S. Department of Energy's recently released National Energy Strategy (NES). The Society believes that the publication of the NES is an important first step in the development of a sound energy policy for the Nation. Significant debate may be expected on many aspects of the plan, and this should be welcomed. Some concern about the NES document has arisen because it is somewhat short on policy specifics. A debate already has begun regarding the commitment to the stated goal of achieving increased energy efficiency.

With respect to the role of coal in U.S. energy policy, the NES document makes the following points:

- Alternative fuels, including those from coal, are expected to decrease U.S. oil consumption significantly by the year 2000 (pp. 4-5 of the NES). Both direct and indirect coal liquefaction processes are candidates, depending upon market conditions (p. 70).
- For the enormous U.S. coal reserves to be of maximum value to the Nation, the U.S. needs to (1) develop new clean utilization technologies, and make them attractive investments for industry; (2) reduce the costs, risks, and environmental impacts of producing liquids from coal; and (3) reduce carbon dioxide emissions associated with the use of coal (p. 12).
- Of the coal consumed in the U.S., over 85 percent is used for producing electricity, accounting for 55 percent of all electricity production in the U.S. Thus, new ways of producing, transporting, and using coal will be of great benefit to the Nation (pp. 98-99).

The ACS agrees with the importance of performing research to address the needs stated or implied within the above points. However, it appears very unlikely that all the stated NES objectives can be met through activities that will be supported by the proposed FY 1992 budget for Fossil Energy R&D.

The Fossil Energy R&D budget contains the bulk of federal support for advanced research on coal and oil shale conversion programs. This advanced research provides the fundamental science and technology base from which actual

process technology development usually is initiated. As noted in the Society's June 20, 1990, testimony before your Subcommittee, there has been a major decline in industrial research in support of the production of alternative fuels from coal. Thus, the science/technology base for the next generation of coal conversion technology cannot realistically be expected to come from the private sector. Federal support for this knowledge base is vital to ensuring the Nation's ability to develop this next generation of technologies for coal and oil shale utilization.

It is important to distinguish between the efforts to foster new technology through the Clean Coal Technology (CCT) program, which mainly emphasizes the development of currently best scientific knowledge into useful clean coal combustion processes, and the equally important efforts to expand the science and technology base that will give rise to new process concepts in the future. The latter is mainly supported by the Fossil Energy R&D budget items shown in the summary table appended. It is this budget that will shape our fossil energy options in the longer term. To cut these budget items significantly is to close off potentially valuable options in exchange for very small total current savings.

Also, it is important to note that the CCT program contributes very little to the solution of the transportation fuels supply problem, either in terms of ensuring supply or in mitigation of environmental effects. The main focus of CCT has been improved processes for electrical generation from coal. The Fossil Energy R&D budget contains most of the significant support for further development of transportation fuels from coal.

A closer look at the budget request for advanced research programs in Fossil Energy R&D is revealing. Overall, the six Advanced Coal Research programs experience a cut of almost 19 percent. The proposed cut for Advanced Research in Coal Liquefaction is 61 percent, for Surface Coal Gasification 62 percent, Control Technology and Coal Preparation 49 percent, and Advanced Research and Technology Development 8 percent. This is hardly the kind of support required to meet the challenges outlined in the NES, when it is noted that the earlier higher levels were barely adequate. In addition, the recommendation in the FY 1992 budget request that Oil Shale programs be "postponed" by cutting all funding in the upcoming year seems also to be at odds with the desire expressed in the NES to explore alternatives to traditional petroleum sources. The need to prepare for increasingly costly petroleum by gradually developing alternative sources is, in the opinion of the ACS, not stated strongly enough in the NES nor adequately supported in the Fossil Energy budget request.

Just how much federal support will it take to keep a stream of useful innovative ideas flowing and to keep capable personnel in those fossil energy areas related to coal- and fossil-derived alternative transportation fuels? Considering the recent dramatic decline of new patent activity in the area of alternative fuels from coal, discussed in the Society's previously mentioned statement of June 20, 1990, the Nation is already in trouble in this research area due to the budget levels of the last few years. The proposed significant cut would be disastrous. With increasing emphasis now placed on devising fossil energy conversion processes of greater efficiency and lesser environmental impact (including lower carbon

The Honorable Marilyn Lloyd

-3-

April 22, 1991

dioxide output), keeping the budget at historic levels is entirely inadequate. An attempt is being made to solve an increasing number of very complex problems with progressively decreasing resources. The research community will be too thinly spread to be effective in any of the key areas.

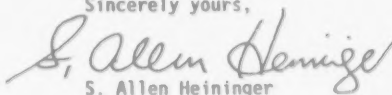
Therefore, the American Chemical Society believes that the budgets for the Advanced Coal Research programs should be increased to levels that at least correspond to those of the early 1980's, the last period of significantly increasing activity in the field. The Society recommends that the total budget for Advanced Coal Research programs for FY 1992 be at a minimum of \$60 million for the programs listed in the Appendix. Further, in the case of Oil Shale, the ACS recommends the establishment of a competitive program for fundamental research and development in FY 1992 at the level of \$5 million.

The Nation cannot take control of its energy future without a viable program of research in the fossil and alternative fuels areas. Scientific strength that can be applied to addressing the needs as outlined in the NES document is essential to the Nation's security and economic well-being. This strength can only be achieved by more meaningful support of Fossil Energy R&D activities. To continue to follow the funding trends of the last several years is to place increasing hope on a perilously small number of energy options, by virtue of starving other options. This path is ill-advised in the face of both recent lessons concerning reliability of petroleum supplies and the negative economic consequences of continued importation of large amounts of oil.

The American Chemical Society, with a membership of over 142,000 chemical scientists and chemical engineers, appreciates this opportunity to bring its expertise and concerns to your attention. The Society's Division of Fuel Chemistry, the authors of this statement, is comprised of about 1000 chemists and engineers with strong interest in fossil and alternative fuels research and development. This Division is one of the largest groups in the Nation concerned with the many technical issues related to development of new, more efficient, cleaner energy production processes involving fossil fuels. The Society and its Division of Fuel Chemistry draw members from industry, academia, and government.

The American Chemical Society urges that you consider these concerns and recommendations as you take action on the Fossil Energy R&D budget for FY 1992. The Society believes that the costs of the recommendations being made are modest when compared to the importance of energy and its impact on our economic well-being, the environment, and national security.

Sincerely yours,



S. Allen Heininger

Appendix

cc: Members, House Subcommittee
on Energy

APPENDIX

**Federal Support for
Advanced Coal Research Programs (a)**
(Dollars in Thousands)

	Control Technology & Coal Preparation Advanced Research	Advanced Research & Technology Development	Coal Liquefaction Advanced Research	Combustion Systems Advanced Research	Fuel Cells Advanced Research	Surface Coal Gasification Advanced Research	TOTAL
1981		\$58,383					\$58,383
1982		51,936					51,936
1983		31,650					31,650
1984		38,996					38,996
1985		30,804	\$5,511			\$3,364	39,679
1986		33,849	5,157			3,379	42,385
1987	\$1,139	26,630	4,470	\$3,248	\$1,350	2,806	39,643
1988	2,042	24,937	6,132	3,351	1,547	2,698	40,707
1989	1,774	25,564	6,902	2,972	1,597	2,679	41,488
1990	2,092	26,466	6,784	2,360	1,458	2,716	41,876
1991	3,206	31,376	8,046	3,141	1,444	1,875	49,088
1992(b)	1,624	28,865	3,106	3,957	1,600	706	39,858

a. Until 1986, Coal Liquefaction Advanced Research and Surface Coal Gasification Advanced Research were funded under Advanced Research and Technology Development as the Processes subprogram. Part of the Direct Utilization subprogram under AR&ID was transferred to Advanced Research within Control Technology and Coal Preparation, Combustion Systems, and Fuel Cells to comply with FY 1988 Congressional direction.

b. Administration's Budget Request.

Source: Budget Justification Books for the Department of Energy.



Department of Energy

Washington, DC 20585

April 19, 1991

The Honorable Marilyn Lloyd
Chairman
Subcommittee on Energy
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

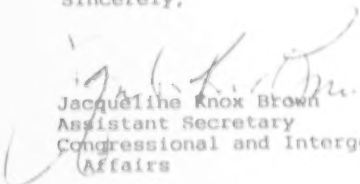
Dear Madam Chairman:

On March 29, 1991, I sent you the edited transcript of testimony given on March 5, 1991 by Robert H. Gentile, Assistant Secretary for Fossil Energy.

The information you requested, transcript pages 21, 22, 24, and 40 was still being prepared at the time. The information has been compiled and is enclosed for the record.

If we can be of further assistance to you or your staff, please contact our Congressional Hearing Coordinator, Renee Wilhite on (202) 586-4277.

Sincerely,


Jacqueline Knox Brown
Assistant Secretary
Congressional and Intergovernmental
Affairs

Enclosures

Committee: House Science, Space
and Technology
Subcommittee: Energy Research
and Development
Date: March 5, 1991
Witness: Robert H. Gentile
Page: 22
Line: 475

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Full implementation of the enhanced R&D effort related to advanced oil recovery will require significant increases over the FY1992 request. Based on the status as of November 1990, we estimate that additional funding of about \$400 million over the four years (FY1993-96) will be needed to fully fund this NES initiative. The profile does not necessarily reflect future funding requests since the EOR budget will have to be considered within the context of our overall requirements and funding request.

<u>Year</u>	<u>EOR Funds (\$ Millions)</u> <u>Light and Heavy Oil</u>
FY93	\$ 65
FY94	\$ 71
FY95	\$138
FY96	\$126

The variations in funding level are due to technically constrained phasing of field tests of advanced recovery processes.

Committee: House Science, Space
and Technology
Subcommittee: Energy Research
and Development
Date: March 5, 1991
Witness: Robert H. Gentile
Page: 24
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The program described in the Oil Research Implementation Plan, which was incorporated into the NES initiative on Advanced Oil Recovery, is designed as a research, demonstration, and technology transfer plan. The Oil Research Implementation Plan originally estimated that the cost of the program would be \$600 million and that the oil target to be addressed by the plan would be 76 billion barrels. The program cost per barrel of the oil targeted in the plan is less than one cent net to the Federal Government. The total program cost per barrel, including industry cost participation is estimated at approximately one and one half cents. Note, however, that actual recovery of oil will depend on many factors including the success of the demonstrations and technology transfer, industry investment in the technology, and several economic factors including oil prices. Also note that oil recovery would continue beyond the years of the program.

The objective of the program is to address the U.S. oil resource at a national level and identify major reservoir types with similar geological and engineering characteristics, which could then be targeted with a limited number of specific economical technologies. Because U.S. operators typically focus on their own holdings, which may encompass several different reservoir types, their technology emphasis is reservoir specific and not the reservoir class approach outlined in the

NES. Assuming successful demonstration of the NES approach, individual operators would bear the costs of broad implementation of the NES developed technologies in their own fields.

Committee: House Science, Space
and Technology
Subcommittee: Energy Research
and Development
Date: March 5, 1991
Witness: Robert H. Gentile
Page: 40
Line: 934

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Concerning the program to develop a hydrogen fuel cell for automobiles, the Office of Conservation and Renewable Energy has had preliminary discussions with the Environmental Protection Agency regarding possible studies to determine the feasibility of utilizing fuel cell technology developed by the National Aeronautics and Space Administration for hydrogen fuel cells for transportation. Funding was not appropriated in fiscal year 1991 for this program and, therefore, to my knowledge, no implementation of grant proposals have been initiated.

APPENDIX III



Department of Energy

Washington, DC 20585

April 24, 1991

The Honorable Marilyn Lloyd
Chairman
Subcommittee on Energy
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Madam Chairman:

On March 5, 1991, Robert H. Gentile, Assistant Secretary for Fossil Energy, testified before your subcommittee on the Authorization of Fossil Energy Research and Development Program.

Following the hearing, you submitted written questions to supplement the record. Enclosed are the answers to questions 7, 8, 10-12, 17-21, 25, 28-30, 32b, 32c, 33a, 33b, and 33c. The remaining questions and answers are still in the clearing process and will be forwarded to you as expeditiously as possible.

If we can be of further assistance to you or your staff, please contact our Congressional Hearing Coordinator, Renee Wilhite, (202) 586-4277.

Sincerely,

A handwritten signature in cursive script, reading "Jacqueline Knox Brown", is positioned above the typed name.

Jacqueline Knox Brown
Assistant Secretary
Congressional and Intergovernmental
Affairs

Enclosures

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 7: Generally, how long are the contract awards?

Answer: Most technical projects have project durations of 1 to 5 years with the majority in the 1 to 3 year range. Small-scale projects are usually designed to run 1 to 2 years and to provide sufficient data to judge the merit for continuance at a larger scale or completion of the research. Larger scale projects typically require longer periods because of the need to design and fabricate experimental apparatus prior to the operational and analysis phases.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 8: How often is each contract reevaluated?

Answer: Typically, each project is required to provide monthly and quarterly reports which define technical progress. In addition, there is typically a major review with project staff at least on a yearly basis. The technical progress of a project is reviewed in comparison to the statement of work, the planned project schedule, funding profile, and the milestones to be accomplished.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 10: Does each project have a set of milestones on which to evaluate the research progress?

Answer: Yes, each research and development project has defined milestones which must be achieved. The number of milestones is dependent on the particular technology and stage of research being conducted under the contract.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 11: Can you provide examples of technologies begun under the Surface Coal Gasification or Control Technology Subprograms that have either gone forward into the Clean Coal Technology Demonstration Program or directly to commercialization?

Answer: Technologies begun under the Surface Coal Gasification and Control Technology Programs that subsequently have gone forward to the Clean Coal Technology program for demonstration or directly to commercialization include: the NOXSO combined NOX and SOX removal process (scheduled for demonstration in Clean Coal III); the General Electric moving-bed hot gas desulfurization process (scheduled for demonstration as part of gasification projects in Clean Coal II and III); the Combustion Engineering two-stage entrained-flow Integrated Gasification Combined Cycle (IGCC) process (scheduled for demonstration in Clean Coal II); the Bechtel confined-zone dispersion flue gas desulfurization process (scheduled for demonstration in Clean Coal III); and the VPI microbubble flotation technology coal preparation process (currently being commercialized).

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 12: Do you foresee any projects within the above categories that will require significant increases in funding within the next three years? If so, please provide a list.

Answer: None of these technologies will require significant increases in funding during the next three years.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 17: At what point will the technology be commercialized?

Answer: This would be a marketplace decision, made by the private sector and heavily influenced by the world oil price and the risk factors associated with building commercial and scale facilities using of these technologies. A necessary but perhaps not a sufficient condition would be a world oil price equal to the "crude oil equivalent" price of the technology (e.g. \$30 per barrel by the end of the century). These are capital intensive facilities and future projections of world oil price have proven to be very unreliable for assessing long-term profitability of energy conversion projects.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 18: At what price do you expect coal-based liquids to be competitive with conventional fuels?

Answer: Current technology would be competitive with petroleum at \$35-\$40 dollars per barrel. Further research and development could reduce this to \$25-\$30 per barrel equivalent by the end of the century. World oil prices are expected to rise to \$30 per barrel or higher by the year 2000 (EIA projection).

QUESTION FROM CONGRESSWOMAN MARILYN LLOYD

Question 19: Please give us the program and performance milestones that the Department uses to judge whether an individual fuel cell project should continue.

Answer: The milestones used by the Department to determine whether or not to continue an individual fuel cell project are as follows:

- o Demonstration that the project has continued potential for addressing the National Energy Strategy goals.
- o Achievability of technical performance targets for the fuel cell stacks/system.
- o Sufficient technical evidence of meeting successful scale-up and durability targets.
- o Development of sound demonstration plans and schedules.
- o Development of credible projections for manufacturing costs in a competitive range.
- o Development of sound marketing strategy and plans.
- o Demonstration of cost-sharing commitments at each stage of a fuel cell project as it progresses.

QUESTION FROM CONGRESSWOMAN MARILYN LLOYD

Question 20: Please give us the projected costs to commercialization of the fuel cell research and development program. Please include costs for all concepts currently under development.

Answer: The current cost-shared R&D efforts in fuel cells are expected to continue until the mid-1990s for molten carbonate and the late 1990s for solid oxides.

Projected funding for fuel cell R&D during this period for these milestones would require Government funding to be at approximately \$40-50 million annually, plus substantial cost-sharing from the private sector. It is also anticipated that field stack and pilot plant demonstrations would follow the R&D program.

Due to the status of the technologies and the risks associated with their development, it is difficult to determine the costs of the follow-on demonstrations at this time. Although it is difficult to provide meaningful estimates of costs beyond the R&D program to take the technologies to the market, it is projected to cost several hundred million dollars for each fuel cell concept to be commercialized.

QUESTION FROM MARILYN LLOYD

Question 21. Several different concepts for molten carbonate are currently under development. At what stage will the Department down select to one technology? What criteria will be used to make that determination?

Answer: The Department expects to complete scale-up development and focus on one technology by the end of CY 1993.

The key criteria to be used for this selection include the performance results, expected commercialization potential, and private sector interest (as indicated by proposed cost-sharing and other measures of interest).

QUESTION FROM CONGRESSWOMAN MARILYN LLOYD

Question 25: What is the development status of those technologies?

Answer: Most of the potential competitors are approaching the proof-of-concept demonstration stage. The first generation IGCC is at the commercial demonstration stage.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 28: An emphasis of the National Energy Strategy (NES) and your budget submission is continuing development of enhanced oil recovery technologies. What is your estimation of reserves that can be captured using the advanced technologies?

Answer: The NES estimates of reserve additions associated with advanced oil recovery research and development are between 20 and 65 billion barrels.

QUESTION FROM CONGRESSWOMAN MARILYN LLOYD

Question 29: Please discuss the most promising advanced extraction technologies in terms of ability to remove remaining oil and in terms of time for commercialization.

Answer: In general, the most promising advanced recovery techniques are: conventional and geologically targeted infill drilling, horizontal and slant drilling, hydraulic fracturing, gel polymer, surfactant and alkali-surfactant, carbon dioxide miscible flooding, thermal (steam) injection with and without additives, and in-situ combustion. Actual application depends upon the reservoir heterogeneity in specific applications. Each of these technologies has been applied by some operators, but with varying degrees of technical and economic success. One of the main objectives of the NES Advanced Oil Recovery effort is to improve our understanding of the impact of reservoir architecture on process, application predictability and performance. The planned activities for various reservoir classes and the selection of field tests are expected to provide this data. Results from the first round of field tests is expected over the next 5 to 8 years. Technology transfer activities will be designed to encourage broad consideration of program results.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 30: Have the Independent Oil Producers participated in the Oil Research program? If so, in what capacity, i.e., advisory, research projects? If not, why not?

Answer: The independent oil producers have provided comment and advice to the Department during the early phase of developing the draft Oil Implementation Plan and continue to participate in the resolution of issues as the plan is implemented. We expect that independent operators will also participate in actual projects resulting from competitive procurements. The first procurement actions are expected to be released this summer.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 32b: Can you quantify the amount of oil that could be recovered with additional funding and whether the targets for recovery of some reserves in the Oil Implementation Plan could be moved forward?

Answer: It is not possible at this time to provide a more definitive estimate of the amount of oil that could be recovered; it would still be in the range of 20 to 65 billion barrels.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 32c: Would additional funding allow the department to characterize more fields more quickly?

Answer: Additional funding would not necessarily shorten the timeframe in which the research is conducted. However, the additional funds would broaden the reservoir data base.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 32c: Would additional funding allow the department to characterize more fields more quickly?

Answer: Additional funding would not necessarily shorten the timeframe in which the research is conducted. However, the additional funds would broaden the reservoir data base.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 33a: You have restructured your Unconventional Gas Recovery program to seek 50% cost-sharing from the private sector. What happens to the ongoing gas R&D activities that are not currently cost-shared?

Answer: Cost-sharing will be required for all ongoing R&D activities. Continuation of these activities will depend on industry interest and support and subsequent level of cost-sharing.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 33b: Will ongoing gas R&D activities be closed-out if cost-sharing is not available?

Answer: Yes, they will be closed out. Activities particularly vulnerable to close-out include National Laboratory and activities involving research in Speculative Gas Resources.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 33c: If ongoing gas R&D activities are closed out, what happens to the research results?

Answer: Research results will be reported in final reports that are required of all activities.

**Department of Energy**

Washington, DC 20585

May 13, 1991

The Honorable Marilyn Lloyd
Chairman
Subcommittee on Energy
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Madam Chairman:

On March 5, 1991, Robert H. Gentile, Assistant Secretary for Fossil Energy, testified before your subcommittee on the Authorization of Fossil Energy Research and Development Program.

At the time of my last letter to you dated April 24, 1991, responses to several questions were still outstanding. Enclosed are the answers to questions 1-6, 9, 13-16, 22, 24, 26, 27, 31, 32a, and 33b. The remaining answer to question 23 is still in the clearing process and will be forwarded to you as expeditiously as possible.

If we can be of further assistance to you or your staff, please contact our Congressional Hearing Coordinator, Renee Wilhite, (202) 586-4277.

Sincerely,

A handwritten signature in dark ink, appearing to read "Jacqueline Knox Brown", is written over the typed name.

Jacqueline Knox Brown
Assistant Secretary
Congressional and Intergovernmental
Affairs

Enclosures

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 1: If Congress does not agree to the transfer of \$150M from the Clean Coal program to fund fossil R&D, what is the Department's contingency plan for the Fossil program?

Answer: The President's proposal to offset the Fossil Energy R&D budget of \$227 million with \$150 million from Round 5 of CCT funds is consistent with the schedule of issuing the solicitation for Round 5 whereby no funding is required for Round 5 until FY 1993 and it is also consistent with the pause that is being proposed after Round 4. We are currently planning to address Round 5 funding during the FY 1993 budget process. However, the language of the request sets the requested appropriations at \$227 million; if the language offsetting that amount with Clean Coal funds is sticken, the net appropriation level would be \$77 million dollars.

QUESTIONS FROM CONGRESSWOMEN MARILYN LLOYD

Question 2: Do you believe that \$77M is adequate to fund activities in FY 1992?

Answer: No, it is not adequate. The intent of the President's budget is to provide \$227 million.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 3: Which programs will be closed-out and which will continue?

Answer: Funding at the level of \$77 million is unrealistic and is not what the Administration intends. It would be counter-productive to speculate on close-out or continuance of any program at that low budget level.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 4: Please discuss the goals of the fossil research and development program.

Answer: We have a hierarchy of goals and objectives, starting with the following first order goals from the National Energy Strategy (NES).

NES GoalCorresponding Major NES/FE Goal

Reduce U.S. vulnerability to oil supply disruptions.

Aggressively develop advanced oil recovery technology aimed at oil unrecoverable with conventional technology.

Maintain coal's competitiveness while meeting EH&S requirements.

Promote development and demonstration of new coal-fired technology.

Encourage efficient, environmentally sound production of natural gas.

Support R&D on better technologies for natural gas production and use.

Promote diversity of electricity technologies and fuel choices.

Pursue RD&D to improve technology performance and promote the use of clean, abundant, competitive domestic fuels.

A more detailed development of these goals and goals for other Fossil Fuels activities cited in the NES are given below for Coal, Petroleum, and Gas.

Coal

o Securing Future Energy Supplies

- Develop clean, cost-effective derived replacement fuels through direct and indirect liquefaction, mild gasification, and beneficiated coal slurries.
- Develop clean, high efficiency (38-45%) power systems for the near- to mid-term.
- Develop superclean, very high efficiency (45-50%) power systems in the mid-term.
- Develop ultra high efficiency (50-60%) power systems for the longer-term.
- Continue development of end use system alternatives.

o Respecting the Environment

- Develop new superclean emission control systems for the mid-term.
- Develop advanced pre-combustion air toxic control systems for the mid-term
- Increase emphasis on development of clean, cost effective technologies for the disposition or utilization of solid/liquid wastes.
- Investigate new concepts for the capture and disposal of carbon dioxide.
- Develop systems to use coal as an environmental problem solver (e.g., co-firing coal and industrial waste/sewage sludge).

o Fortifying our Foundations

- Raise awareness of the public to coal/energy issues and solutions through CCT outreach program.
- Accelerate transfer of advanced research, high-potential technologies.
- Develop advanced equipment for upgrading powerplants domestically and internationally.

o Increasing Energy Efficiency

- A significant number of the Fossil Energy program activities have increased energy efficiency as a major goal. However, these activities are more supportive of one of the other goals shown above and therefore have the objectives listed above.

Petroleum and Gas

o Securing Future Energy Supplies

- Maximize the economic and environmentally-sound producibility of domestic oil.
- Target is 15 billion bbls of oil in near-term, and 61 billion bbls in mid-term.
- Preserve access to high priority classes of reservoirs, i.e., those at risk of abandonment and having large potential reserves recoverable by future, advanced technologies (near-term).
- Develop and transfer currently defined, advanced technologies (mid-term).

- Define new recovery technologies for oil that is unrecoverable by currently defined technologies (long-term).
- Secure long-term U.S. production of natural gas.
- Increase industry participation in DOE research activities.
- Produce oil and gas in environmentally sound manner.
- Transfer technology to industry.
- Expedite commercialization of oil shale.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 5: The FY 1991 budget contained an initiative for a Laboratory-University partnership relating to Materials Applications with fuel cells. What is the status of this in the FY-92 request and does the Department believe this is a worthwhile research endeavor involving a partnership between a National Laboratory and a University?

Answer: A FY 1991 Congressional add-on of \$500K was used to initiate an expanded program on solid state electrolyte systems research at Pacific North West Laboratories (PNL). The expanded program, which is a \$796K total effort in FY 1991, includes subcontracted research at Washington State University and the Oregon Graduate Institute. The level planned for this research in the FY 1992 Request is \$350K.

The FY 1992 level will provide for continued development of solid oxide fuel cell (SOFC) materials. Research on protonic electrolytes, ceramic membrane materials, electrochemical catalysis and promotion studies and electrochemical process mechanisms will not be continued in this program in FY 1992.

The research in this area is considered worthwhile. Anticipated applications for these materials are solid oxide fuel cells, air separation, hydrogen production, electrochemical systems, electrocatalysts, electrochemical synthesis, fluid clean-up and

sensors. The end result should be more efficient, less polluting and lower cost fossil fuel systems.

QUESTION: FROM CONGRESSWOMAN MARILYN LLOYD

Question 6: Unlike the Fuel Cell or MHD Programs, the Surface Coal Gasification Program and the Control Technology and Coal Preparation Programs consist of multiple small contracts for research that encompasses a variety of coal technologies. Please explain how the contracts are awarded, i.e., what criteria are used to select research contracts?

Answer: Proposal evaluation and resulting contracts are managed by the Morgantown Energy Technology Center and the Pittsburgh Energy Technology Center under Fossil Energy's decentralized management. There are two methods for selection of projects: (1) competitive selection such as Program Research and Development Announcements (PRDA) or Request for Proposals (RFP's) and (2) unsolicited proposal evaluation and selection.

In the competitive solicitation process, the objective of the procurement is announced in the Commerce Business Daily. Proposals in response to the solicitation are evaluated against preestablished criteria which includes both technical and management aspects of the proposal. These include:

Technical

- Sound technical approach
- Concept technical feasibility
- Appropriateness of the effort

Management

- Management expertise
- Skill of key performers
- Cost-sharing

Unsolicited proposals are also accepted for evaluation. They must be unique proposals, innovative in nature, and R&D oriented. However, they must fit into the mix of established program areas and needs. Unsolicited proposals are reviewed on their technical merit including support of the DOE goals and potential for success of the particular effort.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 9: What percentage of the contracts are continued?

Answer: Of the 136 contracts currently active in the Surface Coal Gasification and Coal Preparation and Control Technology area, 67 are follow-on work to previous contracts with the same performers. Of the 72 contracts whose initial period of performance ended in FY 1990, 18 were extended beyond the initial period and 6 had follow-on contracts to the same performers. Therefore, approximately one-third of the contracts that ended in FY 1990 were continued into FY 1991.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 13: Most of the technologies under development in the Clean Coal Program and in the Fossil R&D Programs will reduce emissions of SO₂, NO_x, and particulates. Please discuss the longer-term technologies that will help with CO₂ mitigation. When can we look for those technologies to enter the marketplace?

Answer: The DOE Fossil Energy Program primarily bases its CO₂ mitigation strategy on development of higher efficiency power generating systems since a more-efficient system will emit less CO₂ on a per-kilowatt-generated basis. Examples of high-efficiency systems currently under development include: advanced Integrated Gasification Combined Cycle (IGCC) based on air-blown gasification and hot gas cleanup (45 percent efficiency by 2005, about one quarter less CO₂ emissions than current generation of pulverized coal powerplants); advanced Pressurized Fluidized Bed Combustion (PFBC) based on a carbonizer and pressurized circulating PFB combustor (45 percent efficiency by 2005, about one quarter less CO₂ emissions than current generation pulverized coal powerplants); indirectly fired (i.e., utilizing heat exchangers) turbine systems (47 percent efficiency by 2007, about one quarter less CO₂ emissions than current generation of pulverized coal powerplants); super-high-efficiency IGCC systems based on advanced thermodynamic cycles (50

percent efficiency by 2010, about one third less CO₂ emissions than current generation of pulverized coal powerplants); ultra-high-efficiency MHD and gasification/fuel cell systems (over 50 percent efficiency after 2010, about 40 percent less CO₂ emissions than the current generation of pulverized coal powerplants). Additionally, the DOE Fossil Energy Program is also investigating alternate methods of CO₂ control, including novel sequestering concepts.

QUESTION FROM CONGRESSWOMAN MARILYN LLOYD

Question 14.

The Department has followed their pattern of not requesting research funds for the continuation of MHD development. The project needs two additional years of R&D funding to complete proof-of-concept work. Are you aware of the status of the technology and whether it will be ready to apply for round V of the Clean Coal program?

Answer:

Yes, we are aware that the MHD proof-of-concept program will require an additional two years of R&D funding for completion. The remaining technical issues include the durability and scalability of hardware and the amount of energy that can be extracted. Given the current technology status, MHD may not be ready in the currently scheduled Round V of CCT; although a proposal could be made but the technical risk would be high.

QUESTION FROM CONGRESSWOMAN MARILYN LLOYD

Question 15. Please discuss the status of MHD technology development of our international competitors.

Answer: The U.S. currently leads the world in the development of coal-fired MHD, but the Soviets have the lead on gas-fired MHD. The Soviets are developing both systems; one fueled by gas and the other by coal.

There are over a dozen other foreign countries in Europe and Asia conducting research and development on MHD. Italy appears to be considering large-scale development efforts for coal-fired MHD. Coal-fired and oil-fired MHD systems are being investigated by China and Japan at facilities up to 5MW thermal input. No foreign systems are near commercialization.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 16: The Department has funded development of both direct and indirect liquefaction technologies. Is one process more economical than the other? What is the difference in cost per barrel of liquid produced?

Answer: It is helpful to describe the economics of these two technologies in terms of the "crude oil equivalent" price; that is, the world price of oil at which one or both of these technologies would be competitive. This is because they produce different types of products that have different market values relative to crude oil. Direct liquefaction produces a distillate hydrocarbon which can be used as feedstock in existing petroleum refineries to produce a full spectrum of specific liquid fuels (gasoline, diesel fuel, jet fuel, and heating oils). Indirect liquefaction technology can be directed to the production of more-specific, high-valued end products such as high-quality diesel fuel blending stock and oxygenated octane enhancers for use in reformulated gasoline. In that sense, the two processes should be viewed as more complementary than competitive. There is little or no difference in these technologies in terms of "crude oil equivalent" price although production costs favor direct liquefaction by several dollars

per barrel. The current technology would be competitive with crude oil at \$35-\$40 dollars per barrel. The research goal is to lower costs to the range of \$25-\$30 per barrel by 1997.

QUESTION FROM CONGRESSWOMAN MARILYN LLOYD

Question 22.

What is the status of the Solid Oxide program in terms of commercialization potential? How many different approaches are being funded by the Department for advanced concepts?

Answer:

The Department is funding the development of tubular solid oxide systems, which is in the stack development stage at Westinghouse, and the monolithic solid oxide concept, which is in the multicell development stage at Allied Signal.

Solid oxide fuel cells are expected to be competitive for both utility and onsite cogeneration applications.

In addition, the Department's Office of Conservation is funding solid polymer fuel cells with a focus on transportation applications.

QUESTION FROM CONGRESSWOMAN MARILYN LLOYD

Question 24: What technologies might compete with fuel cells in terms of modularity and emissions reduction?

Answer: Fuel cells offer the widest range modularity and lowest emission potential of the advanced fossil fuel fired technologies that are currently under development.

The competing fossil technologies include MHD, other heat engines, and IGCC. Potential non-fossil competitors include wind, solar, and geothermal powered systems.

QUESTION FROM CONGRESSWOMAN MARILYN LLOYD

Question 26: If the Department's fuel cell budget was increased by 15%, please discuss what additional fuel cell activities would be funded.

Answer: The Department believes that the fuel cell FY 1992 budget request provides for a balanced program and a funding increase is not needed. The request continues both molten carbonate contracts at the FY 1991 level, but with an increase in cost-sharing to 50 percent, and continues the Westinghouse solid oxide program at its FY 1991 level, also with an increase in cost-sharing to 50 percent.

However, if the fuel cell budget were increased by 15 percent over the FY 92 requested level, the additional funds could be used to accelerate molten carbonate fuel cell stack research and development and to increase the research effort on solid oxide fuel cells, while maintaining the increased cost-sharing that is appropriate for these prototype development efforts.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 27: In the FY 1991 Appropriations Bill for oil shale activities, there was an \$8M line item for a Western Oil Shale Program cost-shared with Occidental Petroleum. Since passage of the legislation, Occidental withdrew from the activity. Is it possible to reprogram the funds?

Answer: It is our understanding that the funds were appropriated only for work in tract Cb, and can not be reprogrammed. The Department recommends using the funds as an offset against FY 1992 requirements.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 31: Has the Department attempted to seek the independents' views regarding what the focus of a Federal Oil Recovery program should be?

Answer: We have received review comments from independent oil producers since the new oil program plan was released for comment in January 1990. After identifying the first reservoir class to be addressed, we held a meeting to discuss the class, its problems and potential. Many independent producers were contacted and in January 1991, about 40 attended the two day session in Dallas. The first procurements are expected to be released this summer, and independents are expected to participate, especially in the near-term work where improving the economics of current production and extending the life of marginal operations is the focus.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 32a: If the Department's EOR budget was increased by 35%, what activities would be enhanced?

Answer: The FY 1992 budget request for the EOR program represents a significant increase over the current funding level. It supports a balanced program and a further increase beyond the request is unnecessary. However, a 35% increase in the EOR budget could enhance the mid-term field demonstration part of the program by supporting work in a broader spectrum of field situations in each class.

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 33b: Will ongoing gas R&D activities be closed-out if cost-sharing is not available?

Answer: Yes, they will be closed out.

**Department of Energy**

Washington, DC 20585

May 15, 1991

The Honorable Marilyn Lloyd
Chairman
Subcommittee on Energy
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Madam Chairman:

On March 5, 1991, Robert H. Gentile, Assistant Secretary for Fossil Energy, testified before your subcommittee on the Authorization of Fossil Energy Research and Development Program.

At the time of my last letter to you dated May 10, 1991, we explained that the remaining question for the record was not available and that it would be forwarded to you. Enclosed is the answer to that question.

If we can be of further assistance to you or your staff, please contact our Congressional Hearing Coordinator, Renee Wilhite, (202) 586-4277.

Sincerely,

A handwritten signature in dark ink, appearing to read "Jacqueline Knox Brown", is written over the typed name and title.

Jacqueline Knox Brown
Assistant Secretary
Congressional and Intergovernmental
Affairs

Enclosures

QUESTIONS FROM CONGRESSWOMAN MARILYN LLOYD

Question 23: At what stage of development are our competitors in fuel cell development?

Answer: Commercialization efforts are underway in both the U.S. and Japan for the commercialization of phosphoric acid fuel cell systems. The liquid-cooled phosphoric acid technology in Japan is based in part upon technology developed by United Technologies with DOE funding. This technology is available to Toshiba through the International Fuel Cell Corporation (IFC), of which Toshiba is a minority stockholder. The Japanese also control their own funding for phosphoric acid fuel cell development. The U.S. is slightly ahead of Japan and Europe on molten carbonate fuel cells, which are in the stack scale-up development stage. The U.S. is also slightly ahead of Japan and Europe in solid oxide and polymer electrolyte systems, which are at the cell and stack development stage.

NATIONAL
COAL
ASSOCIATION

COAL

April 15, 1991

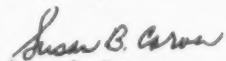
Ms. Cheryl Faunce
Subcommittee on Energy
B-374 Rayburn House Office Building
Washington, D. C. 20515

Dear Cheryl:

In response to Chairman Lloyd's letter dated March 25, enclosed are the answers to questions submitted to Dr. Frank Burke relating to the hearing held March 5 on the Fossil Energy budget request for FY 1991.

If you have any questions, please do not hesitate to give me a call.

Sincerely,


Susan B. Carver
Assistant Vice President,
Congressional Affairs

Enclosure

1130 Seventeenth Street, N.W.
Washington, D.C. 20036-4677
(202) 463-2625

Questions for the Record
Mr. Frank Burke
National Coal Association

March 25, 1991

1. Many first generation technologies are being demonstrated in the Clean Coal Technology demonstration program. What second generation technologies should we be considering at the R&D level now?
2. Are technologies available that capture CO₂ and if so, what is the status of their development? What would be the cost of implementing the technologies?

1. Many first generation technologies are being demonstrated in the Clean Coal Technology demonstration program. What second generation technologies should we be considering at the R&D level now?

Projects selected under the first three rounds of the Clean Coal Technology demonstration program can be grouped into four general categories. These include seven projects dealing with combustion modifications to conventional coal-fired boilers, seven projects involving fuel preparation, eleven projects involving advanced generating systems, and thirteen projects to demonstrate flue gas clean up technologies. Advanced technologies are now under development at the laboratory and pilot plant scale. These include power generation systems such as fuel cells and magnetohydrodynamics, synthetic fuel production processes, advanced high-efficiency flue gas clean-up technologies, and advanced heat engines for direct coal utilization. In general, these technologies address two principal needs. The first is to increase energy efficiency and minimize the environmental impact of coal use in its conventional electric-power generation market. The second is to exploit the low cost and supply security of coal as a new fuel in unconventional markets, particularly transportation.

2. Are technologies available that capture CO_2 and if so, what is the status of their development? What would be the cost of implementing the technologies?

Carbon dioxide can be captured by cryogenic or acid-gas adsorption technologies. Although these technologies are well-established in some industrial applications, they have not been demonstrated at a utility scale. The costs, although difficult to estimate accurately, are unlikely to be economically acceptable in the current electrical power market. The more cost-effective approach to reducing CO_2 emissions from coal combustion is to utilize high-efficiency generating technologies, such as IGCC and PFBC, which minimize CO_2 emissions on a unit-power-generated basis. In the longer term, ultra-high efficiency technologies, such as fuel cells and magnetohydrodynamics are expected to become available for further reducing CO_2 emissions.

Mr. Frank Schora
M-C POWER CORPORATION

To: Attention Cheryl Faunoe
S-374 Rayburn House Office Building
Washington, D. C. 20515

Following is the response to the question submitted on March 25, 1991 for answer:

Question

1. If we refer to the three types of fuel cell development (phosphoric acid, molten carbonate, solid oxide) as the 1st, 2nd and 3rd generation technologies - what are the increased benefits of each, i.e. what does molten carbonate offer over phosphoric acid, and what additional benefits will we receive from solid oxide?

Answer

The benefits of molten carbonate type fuel cells (MCFC) over phosphoric acid type cells (PAFC) are significant. PAFCs operate at relatively low temperatures, 300-500°F, while MCFCs operate at 1200°F. This results in significant differences. At the low temperature, PAFC's produce waste heat at a temperature which limits its use to essentially producing hot water for heating. At the higher temperature of operation, MCFCs can produce high quality steam which can be used for air conditioning (chillers), industrial uses, and in the larger multi-megawatt systems, can be used in a bottoming cycle for additional power generation. Because of the platinum catalyst used on the PAFC electrodes, coal gas or reformed natural gas must be processed to make it free of carbon monoxide which, if introduced to the fuel cell even in low concentrations, will inhibit the fuel cell operation. The MCFC because of the

higher temperature of operation can use either nickel or copper electrodes, does not require platinum, and is not sensitive to carbon monoxide. Studies indicate that the overall cost of manufacture of MCFC stacks and system will be lower than PAFC stacks and systems. In addition, MCFC's operate at a higher efficiency than the PAFC's. It is also possible with MCFCs to reform natural gas within the fuel cell by introducing an appropriate catalyst into the stack. This results in very high fuel to electric efficiencies.

The solid oxide fuel cell (SOFC) operates at a temperature of 1,800°F. As with MCFC's, waste heat can be effectively utilized because of the high temperatures. Also at this higher temperature, internal reforming of natural gas is possible without the use of additional catalyst. Unlike the MCFC, the SOFC does not require recirculation of carbon dioxide with the air being fed to the stack for proper operation, which simplifies the gas handling system somewhat.

It has been reported that the manufacture of SOFC may be less expensive than MCFC, however, significant breakthroughs in manufacturing techniques will be necessary to achieve this.

The so-called stacking of SOFC cells is a big problem yet to be satisfactorily resolved and may lead to practical use of SOFC only in small applications less than 250 kW.

IPM 1048-910411-154150177

P.1

** To: GRUVER,J.A (WES2109)
 Cc: DOLLARD.W (WES4016)
 From: DOLLARD.W (WES4016) Delivered: Thu 11-Apr-91 17:07 EDT Sys 1048
 (30)
 Subject: Question for the Record
 Mail Id: IPM-1048-910411-154150177

1. If we refer to the three types of fuel cell development (phosphoric acid, molten carbonate, solid oxide) as 1st, 2nd and 3rd generation technologies - what are the increased benefits of each, i.e. what does molten carbonate offer over phosphoric acid, and what additional benefits will we receive from solid oxide?

ANSWER

The molten carbonate fuel cell operates at higher temperatures, i.e. 1150RP as opposed to 400RP for the phosphoric acid fuel cell. The increased temperature is high enough to potentially allow an economically combined cycle, i.e. using the exhaust heat of the fuel cell to run a steam turbine to increase overall plant efficiency or for high quality process heat.

The solid oxide fuel cell operates at still higher temperatures, i.e. 1800RP, so that the quality of exhaust heat is even better. In addition, the solid oxide fuel cell system is simpler than the molten carbonate system and, therefore, promises to be easier to operate and maintain. In addition, it should be more tolerant to sulphur in the fuel gas stream and thus more directly applicable in coal gasification power plants.



Inter-Office Correspondence

To: J. T. Sanderson

From: M. W. Snow

cc: P. E. C. Bryant

LA-91-041

29 March 1991

Subject: Question Regarding Relative Merit of Mainstream Fuel Cell Types

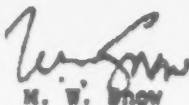
You requested a response to the subject question in terms of the progressive benefits of molten carbonate (mc) and solid oxide (so) technologies, respectively, over phosphoric acid (pa).

Mc fuel cells operate at a temperatures of 650°C, 400 - 500°C above pa fuel cells. At that temperature, several benefits accrue:

- electrode kinetics are faster, and the expensive noble metal catalysts required by lower temperature cells are not needed
- voltage efficiencies are higher and irreversible losses are lower
- the tolerance of the cell to substances which poison the catalysis of the pa cells (such as carbon monoxide, which is actually used as a fuel in the mc cells) is increased
- practical and efficient cogeneration cycles can be integrated with the fuel cell system to use the high quality heat which its reactions produce
- reforming of a variety of hydrocarbon fuels can be accomplished internal to the fuel cell.

So fuel cells operate at 1000°C, and in addition to advancing the benefits stated above,

- the cell is all solid-state; no corrosive electrolytes are used
- recycling of carbon dioxide to the cathode (necessary in practical mc cells) is not required
- there is more tolerance to sulfur containing contaminants
- higher power density is achievable through the use of thin film components.



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